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IMPROVEMENT OF STUDENTS' PERFORMANCE ON TITRIMETRIC ANALYSES IN BREMAN ASIKUMA SENIOR HIGH SCHOOL USING STUDENT TEAM ACHIEVEMENT DIVISION: A CASE STUDY

WINFRED AGADZI

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A Thesis in the Department of Science Education, Faculty of Science Education, submitted to the School of Graduate Studies in partial fulfilment of the requirement for the award of degree of Master of Philosophy (Science Education) in the University of Education, Winneba

MAY, 2020

DECLARATION

STUDENT'S DECLARATION

I **Winfred Agadzi**, hereby declare that this thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely the result of my own original research and that no part of it has been presented, either in part or whole, for another degree in this university or elsewhere.

CANDIDATE'S SIGNATURE.. DATE.................

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of the thesis was supervised in accordance with the guidelines on supervision of thesis as laid down by the University of Education, Winneba

SUPERVISOR'S SIGNATURE... DATE..........................

PROFESSOR JOHN K. EMINAH

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DEDICATION

This study is dedicated to my entire family for their continuous support, prayers and encouragement to me at all levels of my education especially to my lovely wife Yvonne Etornam Yamble, my daughter Dereline Delalinam Agadzi, my son Jeremy Selorm Agadzi, my niece Josephine Agadzi and to my mother Matilda Amevor.

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ABBREVIATIONS

MOESS	Ministry of Education, Science, and Sports
CRDD	Curriculum Research and Development Division
SHS	Senior High School
STAD	Students Teams Achievement Division
WAEC	West African Examinations Council
WASSCE	West African Senior Secondary School Certificate Examination

ABSTRACT

This study sought to improve the performance of students on titrimetric analysis in Breman Asikuma Senior High School using student team achievement division. It was also intended to find out the views of the students on the use of the STAD to teach titrimetric analyses and also find the differences in the performance of male and female students on titrimetric analyses using the STAD as the intervention. The study was a case study design using the action research approach. The sample for the study was ninety-five (95) second year chemistry students in two intact classes using purposive sampling technique. Achievement tests (pre-intervention, intervention and post-intervention tests), informal interview and questionnaire were used as data collecting instruments and the intervention tool used was the STAD. The instruments were pilot –tested to establish the reliability coefficient and were validated by the research supervisor in the Department of Science Education, University of Education, Winneba as well as some other departmental lecturers and experienced chemistry teachers in Breman Asikuma SHS. The scores obtained from the achievement tests were analysed using Excel spread sheet and Statistical Package for Social Science (SPSS) version 20 to find out the level of achievement of students after the intervention. Overall findings of the study showed among others that the students had difficulties in some scientific terminologies associated with titrimetric analyses, use of indicators, and manual skills acquisition in titrimetric analyses. There was a great improvement in the performance of the students in general and that of the females over the male students after the intervention as they performed better in the post-intervention test than the pre-intervention test; the students had an overall positive perception concerning the use of the STAD as a teaching and learning technique. It was recommended among others that interested researchers could conduct research into the relative effectiveness of use of the STAD in teaching chemistry topics or teachers incorporate it in any other method of teaching in order for the students in the school to reap the benefit.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter includes the background to the study, statement of the problem, purpose of the study, objectives of the study and research questions. The significance of the study, ethical considerations, limitations and delimitation of the study, as well as definition of terms, abbreviations and the organization of the thesis are also presented.

1.1 Background to the Study

Chemistry is the study of matter and the changes it undergoes (Ameyibor & Wiredu, 2001). Chemistry is undoubtedly the central science that forms the basic foundation of many disciplines. It is often called the central science, because a basic knowledge in chemistry is essential for students of biology, physics, geology, home economics and many other related science programmes.

In spite of this important position of chemistry among other science and science related disciplines, chemistry students' academic performance in Breman Asikuma Senior High School in titrimetric analysis have for many years remained a matter of serious concern for educational administrators and chemistry teachers of the school.

Titrimetric analysis is a common quantitative activity carried out by students in introductory chemistry classes in various universities and senior high schools in Ghana. The topic has been a regular component of introductory chemistry curricula for decades, and receives wide coverage in introductory texts and related laboratory manuals (Dorin, 2009; Wilbraham, Staley & Matta, 1996; Dingrando, Gregg, Hainen, & Wistrom, (2002)). Some introductory texts (Dingrando et al., 2002) extend the topic to include details of titration curves. According to Eminah (2008) the methods of titrimetric analysis include: the preparation of a solution of the substance to be analyzed, the preparation of a solution of another substance by means of which the analysis is performed, the addition of one solution from a burette to measured portions of another solution in a conical flask (titrant) and the use of a substance known as an indicator which by a change of colour makes the completion of the reaction known. Titrimetric analyses also involve the correct manipulation of the apparatus and equipment used in titration, accurate measurements skills of volumes and the subsequent relevant calculations which form a very important aspect of quantitative analysis in chemistry practical.

In spite of how relevant and basic titrimetric analyses are, the science students in general and the female science students in particular of Breman Asikuma Senior High School have numerous challenges with all the above mentioned processes involved in titrimetric process. Science students in Breman Asikuma have fundamental difficulties in manipulating the apparatus and equipment used in titration and also lack basic concepts and skills in titrimetric process including the relevant calculations.

Efforts made through interactions with teachers in the school to discover the remote causes of the students' persistent failure revealed that the chemistry teachers mainly adopted the traditional method in the teaching and learning of titrimetric analyses. A number of factors have been posited for the massive decline in students overall performance in chemistry at WASSCE in general and in internal examinations in particular and include but not limited to inadequate instructional methods (Omwirhiren, 2008 & Omwirhiren, 2012); inadequate laboratory facilities (Eze, 2010) and lack of practical skills.

Omwirhiren (2008) observed that, students have many weaknesses in the practical aspect of the chemistry examination and this is not unconnected with the rush hour and manner in which this aspect of the syllabus is taught in some senior high schools. The authors hypothesized that if practical chemistry is taught in harmony with the theory of acid-base titration, the performance of students would be enhanced and concepts comprehended.

Chemistry is an experimental science which relies primarily on the harmony between theory and practical (Muhammad, 2014). The understanding of concepts in practical chemistry will assist in enhancing student's understanding of chemistry (Ikoebi, 2010). Students have difficulty in making connections between the sub disciplines of chemistry and the link between practical work and theory is often less than obvious because of the approach adopted by teachers in insstruction (Cole, Janes, Mclean & Nicolas, 1998). In chemistry teaching, the importance of harmonizing practical work with theory cannot be over-emphasized. Omolade (2008) stated that if the academic achievement of students is to be enhanced, learners must have a deep understanding of the basic concepts behind the practical tasks they engage in. This is because the observations and experiments, students carry out are meant to confirm some theories and the application of concepts.

Quality teaching and learning are the cornerstones of education and no education system can function without effective teaching and learning.

The various methods of instruction are normally anchored on some theories of learning. Notable among these theories in recent times is the theory of constructivism. The constructivists hold the view that, learning should primarily involve the learner and facilitate the learners' ability to conceptualize learning contents. Thus, meaningful learning takes place when the learners are socially involved. Teaching methods that enhance students' subject matter conceptualization and student - student as well as teacher - student interactions could enhance achievement as students can learn from each other's concepts what they could not learn directly from the teachers. Such learning approaches are better suited for teaching and learning science concepts including titrimetric analysis in chemistry. Ability to achieve these objectives of teaching titrimetric analysis in chemistry requires proper conceptualization of chemistry concepts. This would require teaching and learning approaches that could make students practice science knowledge gained, achieve good grades in chemistry and apply the learned concepts in their daily lives as scientists.

Two methods that come to mind at this point are Cooperative Learning and Student Team Achievement Division (STAD). STAD is one of the many vital strategies in cooperative learning. It is highly student-centered.

Cooperative learning is the instructional use of small groups so that students work together to maximize their own and each other's learning (Rose, 2014). Techniques involved in cooperative learning include: Think-pair-share, Jigsaw, Jigsaw II, Reserve jigsaw, Inside-outside circle and Reciprocal teaching (Schul, 2011). Research-based evidence has shown that cooperative learning improves students' learning outcomes and educators have recognized cooperative learning as a beneficial teaching-learning technique for different subjects (Gunter, 2003). Cooperative learning has been one of the interventions used by teachers to foster academic enhancement among students. On the other hand, some educators utilize cooperative learning in order to ensure active learning among the students who are the core of the educative process. Active learning was a provision for students to be responsible for their own learning through constant idea conception and social interaction with their co-learners (Kutnick, Ota & Berdondini, 2006).

Cooperative learning is seen beneficial, especially in a diverse classroom environment where students differ by religion, culture, race, etc. With this comes the need to choose teaching and learning strategies that would aid in educating a variety of students. More so, that there has been a demand to integrate other skills in the academia, especially social skills so students will be able to succeed beyond the academic environment. Closely related to cooperative learning is Student Team Achievement Division (STAD) which is another innovative instructional method that also has the potential for improving academic achievement. STAD has been used for a wide variety of subjects, from mathematics to language, arts to social studies, and has been used from second grade to college level (Rai, 2007). The STAD method is most appropriate for teaching well-defined objectives with single right answers, such as mathematical computations and applications, language usage and mechanics, geography and map skills, and science facts and concepts. However, it can easily be adapted for use with less well-defined objectives by incorporating more open-ended assessments, such as essays or performances (Rai, 2007).

Students Team Achievement Division (STAD) according to Rai (2007) is one of the many strategies in cooperative learning, which helps promote collaboration and self-regulating learning skills. The reason for the selection of STAD is good interaction among students, improve positive attitude towards subject, better self-esteem, increased interpersonal skills. STAD also add an extra source of learning within the groups because some high achievers act as a role of tutor, which result in high achievements. Finally, it enables the students according to the (requirements of the modern society by teaching them to work with their colleagues competently and successfully as explained by Balfakih (2003). The findings of Balfakih (2003) have indicated that in teaching 10th grade chemistry, students team achievements division (STAD) is a more effective teaching method than the traditional-teaching method.

Khan (2011) conducted a similar study, by studying the effects of STAD on the achievement of ninth-grade students in a diverse cultural general biology class. The experimental group having the combination of both black and white students had a significant increase on the academic achievement scores. Face to face, interactions in the classroom has an intense effect on the societal, cognitive, and scholarly development of students (Kahn, 2011). According to Kahn (2011) the learning process in which the interactions of students occur led to acquisition of social and language skills. As Hagen (2000) noted, the cooperative learning is a universal set of STAD, more successful as a teaching/learning approach compared to customary teaching methods.

A search of the available literature did not reveal any reference to the use of the STAD to promote student-learning in titrimetric analysis. Modern day theories of titrimetric analysis earmark the significance of student-centered learning where much learning is done through student-student interaction. STAD was one cooperative learning strategy that boosted not only collaboration, but also independent learning at the same time (Rai (2007), Norman (2005), & Slavin (1996). This strategy is very applicable and adaptable to different levels of students since classes are organized based on heterogeneous groupings. It has also ensured that students should have accelerated learning since STAD converges on the precepts that students work together to learn and at the same time would be responsible for their own learning.

Slavin (1996) also added that, the goal of STAD is to achieve students learning as a team and to capitulate that as task would not be completed if not all members understand the content. As such, Slavin (1997) delineated the three STAD precepts which are responsibility, teamwork and equality among the students.

It is in view of this that, the researcher decided, to use STAD to improve the performance of students on titrimetric analysis in chemistry in Breman Asikuma Senior High School.

1.2 Statement of the problem

Science students at Breman Asikuma Senior High School are most often given extra tuition among others but the performance of the students in titrimetric analyses has not shown any significant improvement over the years. This challenge faced by the science students in titrimetric analyses especially the female science students have come up at several Departmental and Academic Board meeting at Breman Asikuma Senior High School. Besides, the poor performance of students in quantitative analyses has been reported quite some time now by WAEC Chemistry Chief Examiner (WAEC, 2013 – 2017). The reports of the chief examiners' (WAEC, 2013 - 2017) consistently indicated a downward trend in the performance of students in different aspects of chemistry including titrimetric analysis. The weaknesses reported on exceeded the strong points of the candidates in qualitative analysis. It was also reported that while many candidates could not use mole ratio in their calculations, some candidates did not abide by instructions given which might have affected their titre values. Additionally, it was also reported that the huge values recorded by most students for the determination of the average titre for the acid used in the titration indicated that students had challenges in identifying colour change at end points. Also some candidates could not use the formula for calculating the concentration of reactants correctly e.g. $C_1V_1 = C_2V_2$. The substitution of figures into this formula was poorly done. Many candidates also lost marks for not leaving their answers in the appropriate significant figures. Additionally, some students did not follow the procedures outlined in the question thereby messing up the answers (WAEC, 2013 - 2017).

Although the Chief Examiners reports (WAEC, 2013 - 2017) have been offering suggestions to address the candidates' weaknesses, the situation appears to remain the same. This points to the complex nature of factors that affected students' performance on titrimetric analysis in chemistry and continue to remain same in the study area where the researcher teaches chemistry. Since students are examined on this in the WASSCE chemistry practical examination, teachers always teach it prior to examination, putting a lot of pressure on students due to its abstract nature. The topic is also practical – oriented but the lecture instructional method employed by most teachers allows students to end up memorizing facts, thus preventing them from getting hands – on experience. Although studies have been conducted into aspects of the teaching and learning of some concepts in chemistry using cooperative learning and other strategies, no study to that effect has been conducted in the area of this study using the STAD.

For this reason, this study was designed to use the STAD to improve science students' performance in titrimetric analysis at Breman Asikuma Senior High School. Chemistry concepts cannot be taught in the abstract (Basilli & Sanford, (1991), Slavin, (1996) & Acar & Tarhan, 2008). Students need to form groups and exchange ideas in the form of cooperation on any given concept for them to understand better. The literature contains report on the positive effects of the STAD on science students' cognitive achievements. It is for this reason that this study has adopted the STAD as a method of improving the performance of the science students on titrimetric analysis in chemistry at Breman Asikuma Senior High School in the Central Region of Ghana.

1.3 Purpose of the Study

The purpose of the study was to improve the performance of students on titrimetric analysis in Breman Asikuma Senior High School using student team achievement division (STAD). Titrimetric analysis was chosen among the several areas in chemistry due to the several alternative conceptions and difficulties on the part of students.

1.4 Objectives of the Study

The objectives of this study were to determine the:

1. Difficulties the students encounter during theory and practical lessons on titrimetric analyses.
2. Effect of the STAD on the students' performance on titrimetric analyses.
3. Views of the students on the use of the STAD to teach titrimetric analyses.
4. Differences in the performance of male and female students on titrimetric analyses using the STAD as the intervention.

1.5 Research Questions

In view of the objectives enumerated above, the following research questions were addressed:

1. What difficulties do the students encounter during theory and practical lessons on titrimetric analyses?
2. What is the effect of the STAD on the students' performance on titrimetric analyses?
3. What are the views of the students on the use of the STAD to teach titrimetric analyses?

4. What are the differences in the performance of male and female students on titrimetric analyses using the STAD as the intervention?

1.6 Significance of the study

The researcher hopes that the research can give some benefits in chemistry teaching and learning process especially in the teaching of titrimetric analysis. It is expected that the research can give useful input to the teacher in improving the quality of teaching and learning process of titrimetric analysis to Breman Asikuma Senior High School science students. By understanding the results of this study, the teacher can be careful in selecting teaching technique in the class. It is also expected that the school can compare the advantages of STAD technique to other techniques. Additionally, it is hope that the result of the study can help the students in learning titrimetric analysis, therefore there would be a significant improvement in the performance of science students in chemistry. Besides, STAD as a technique for teaching titrimetric analysis can make the students enjoy the titrimetric analysis processes and feel the interest in learning chemistry. To other researchers, this study is just one effort in improving the students' skills in titrimetric analysis. It is hoped that this research would be useful to conduct the other researches on the similar problems. Finally, the strategy would add to the existing literature on STAD strategy in improving students' performance in chemistry and as a source of information for researchers in the academia

1.7 Limitations of the study

Limitation are potential weaknesses in research study and are out of the researcher's control (Simon & Goes, 2013). They limit the extensity to which a study can go, and sometimes affect the end results and conclusions that can be drawn. Again, they are the shortcomings, conditions or influences that cannot be controlled by the researcher that place restrictions on the methodology and conclusions. The following limitations can be observed regarding this study:

The researcher limited himself to Breman Asikuma Senior High School because this was where the researcher taught. Due to confinement of the research at Breman Asikuma Senior High School, it might not be proper to generalize the results. The study involves students and there was the tendency for these respondents' to give responses which were not the true reflection of the actual situation. This might affect the results of the research. Also there may be challenges with teachers who handle those classes for their periods to be used on some occasions for the research activities.

Another limitation was related to the absenteeism on the part of some of the students'. Some students' absented themselves from school due to truancy at the time of intervention and this might introduce error and the results of the study would be affected.

1.8 Delimitations of the study

Delimitations are characteristics that arise from the conscious exclusionary and inclusionary decisions made during the development of the study plan (Dusick, 2011). Dusick (2011) explained that it involves delineating properly the boundaries of the study that is, what would be covered and what would not be covered in the study. It is a way of trying to bring the problem into sharp focus. Setting delimitations and subsequent justifications to help the researcher to maintain objectivity in the study. It also helps other researchers to reconstruct a study or advance future research on the topic. Furthermore, delimitation provides the scope within which researchers conclude their findings and determine a study's reliability or external validity. The delimitations were under the control of the researcher. Delimiting factors included the choice of objectives, the research questions, variables of interest, theoretical perspectives the researcher adopted and the population (Simon & Goes, 2013). In the light of the above, the following were the delimitations of the study:

The study was restricted to Breman Asikuma Senior High School in the Central Region of Ghana. This was due to proximity and accessibility of the research subjects and also as a teacher in the school. The study was also restricted to SHS 1 and SHS 2 science students' because adequate time was needed to prepare them and monitor their performance with time before they write the final examination. Finally, titrimetric analysis was chosen because major questions were set on it in their chemistry practical which the students need to master before they write their final examination, West African Senior School Certificate Examination (WASSCE).

1.9 Definition of Terms

Titrimetric Analysis: It is a method of analysis in which a solution of the substance being determined is treated with a solution of a suitable reagent of exactly known concentration.

Performance: Refers to the students' scores obtained in a test.

Practical: Refers to the experiments carried out by the learners themselves or with the help of the teacher during the learning.

1.10 Organization of the Thesis 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 delimitations and ethical considerations. The second chapter consists of a review of related literature from which was derived a theoretical framework for the study, conceptual framework and empirical evidence. The third chapter outlines the detailed information of research methodology employed in the study. The fourth chapter presents the data collected and their analysis and discussions. The fifth chapter presents the summary of the study, conclusions, and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter deals with the review of the related literature. The review was done under the following sub-headings: titrimetric analysis, nature of chemistry curriculum, case study and action research. This chapter also reviews cooperative learning, student team-achievement division, gender and performance in senior high school practical chemistry and empirical review.

2.1 Titrimetric Analysis

Quantitative analysis is a procedure used to estimate the concentration of an acid or base or any other substance in solution (Asamoah, 2013). It makes use of volume of the substance, which reacts with a known volume of another. Using this method the substance with known concentration is used to estimate the concentration of the unknown substance from the stoichiometric equation. In volumetric analysis the point of neutralization is the equivalence point. Equivalence point denotes the point in the reaction at which an equivalent amount of the base neutralizes the acid. At the equivalence point there is no excess of acid or base and the solution contains salt and water only. The point at which the base has been completely neutralized by the acid called the end point is shown with the colour change by the addition of an indicator. To reduce error, the equivalence point and the end point should occur at the same pH range. This means that the chosen indicator should experience a colour change only at the pH of the equivalence point. Titrimetric analysis volumetrically measures the amount of reagent (titrant), required to complete a chemical reaction with the analyte. A general chemical reaction for volumetric analysis is

$aA + tT \rightarrow products$

where a moles of analyte A contained in a sample reacts with t moles of the titrant T.

2.2 Indicators

According to Asamoah (2013), indicators are weak organic acids or bases (dyes or plant extracts) which change colour in acidic or alkaline medium depending on the pH. The end point is determined with the help of these indicators.

2.2.1 Choice of Indicators in Titration

1. The choice of indicators for acid-base titrations depend on the pH of the salt solution formed during the titration as shown in tables 2 and 3 below.
2. If the pH of salt solution is acidic, methyl orange is used.
3. If the pH of the salt solution is basic, phenolphthalein is used
4. The indicator must change colour over a certain pH range.

2.3 Students' Difficulties with Titrimetric Analysis and the Care and Correct uses of Apparatus

Another important area of titrimetric analysis is the care and the correct uses of apparatus. It helps in getting accurate results in titrimetric analysis process. However, students have a lot of challenges in handling the apparatus in titrimetric analysis appropriately hence arriving at inaccurate results most often. The under listed are some care and correct uses of the titrimetric analysis apparatus.

1. Burette must be clamped vertically and **not** slanted.

2. All apparatus must be thoroughly was with tap water and rinsed with distilled water immediately before and after use.

3. Before filling up the burette (or pipette), rinse it with the solution to be used.

4. Before sucking up a solution, make sure that the tip of the pipette is well below the surface of the solution.

5. Avoid air bubbles from being trapped during the filling of the burette and pipette.

6. Take readings with the eye level with the bottom of the meniscus to determine the correct volume of solution in a graduated pipette or burette.

7. In emptying the pipette, ensure complete drainage but take care **not** to remove any suspended liquid in the jet by blowing it out.

8. While draining the pipette, the tip of the pipette must be lowered until it just touches surface of the alkali in the conical flask.

This is to ensure that correct volume of solution is transferred into the flask.

9. Do not rinse the conical flask with the solution to be pipette.

10. Distilled water is used in washing the sides of conical flask during titration.

11. Use the funnel to pour in the acid above the zero mark on the burette and immediately remove it from the burette before adjusting to the initial burette reading.

2.5 Titration curves

According to Silberberg (2007) an acid - base titration curve is very important where it gives an idea of how successful the titration is. It is also useful in the selection of the appropriate indicator for titration. However, it is rarely used to find the volume of reagent solution at the equivalent point because it is easier to use an indicator and read the volume from the burette as we shall see. The titration curve can be obtained usually by drawing a relationship between the volume of the standard solution (titrant) cm^3 B (x - axis) and any property of the conical flask solution (y - axis) such as pH (acid – base titration) the concentration of the analyte pA or the titrant pB as shown in Figure 1.

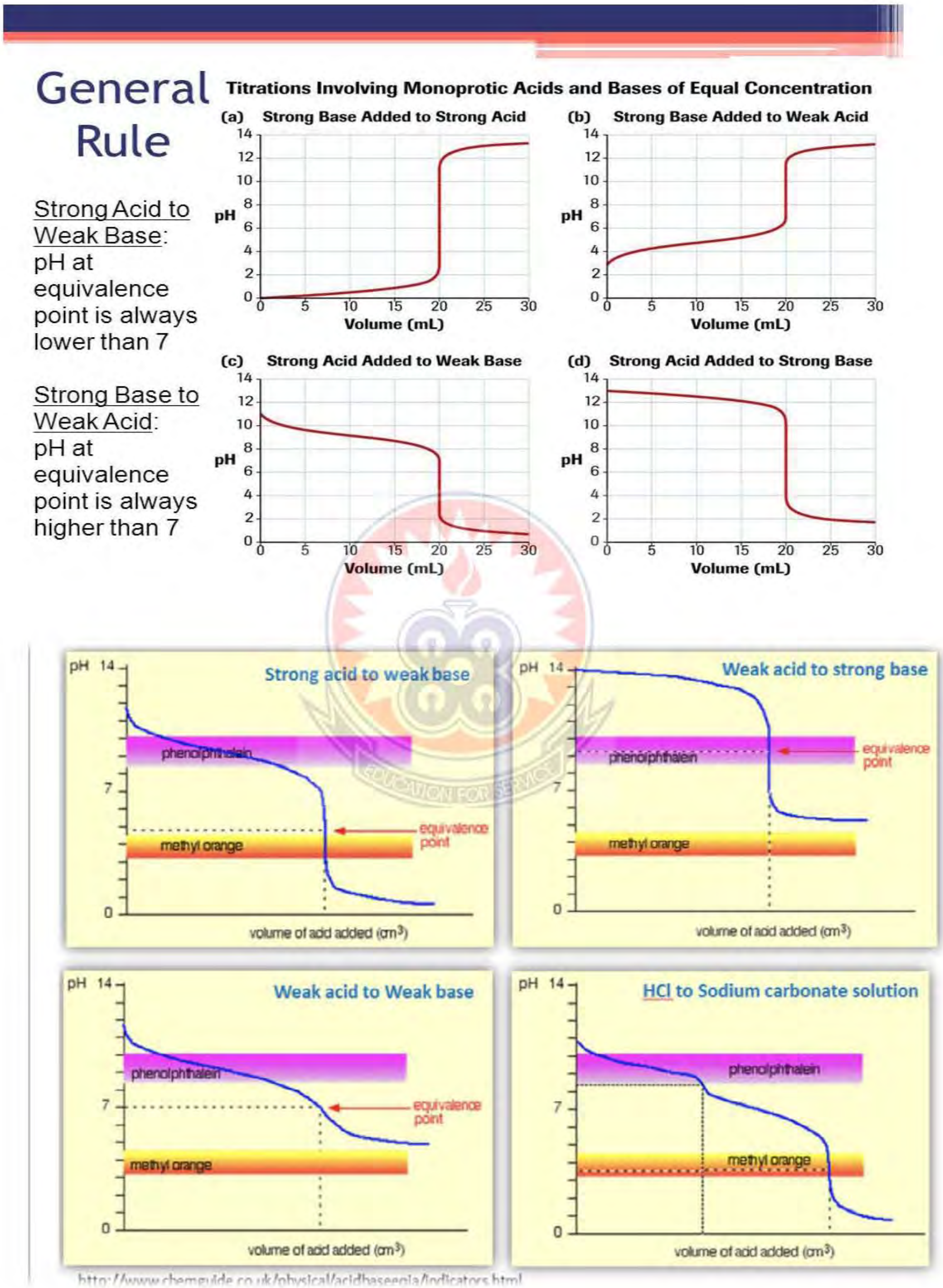

Figure 1: Titration curves

2.6 Importance of Titrimetric Analysis

Titrimetric analysis is a highly precise and easy process that gives fast results and only simple apparatus are required (Ameyibor & Wiredu, 2001). Titrimetric analysis takes place in a wide variety of situations such as in industrial laboratories, hospital laboratories, and forensic science laboratories. Titrimetric analysis is also important in environmental chemistry, food, beverage and pharmaceutical industries. Thus, having a prime importance the titrimetric technique is widely used in chemistry laboratory. This technique is taught in senior high schools and at tertiary levels and as being its nature of quantitative measurement, all the experimental steps are sensitive which demand careful handling. A small mistake can perform all the further results and calculations wrong.

2.7 The Nature of the SHS Chemistry Curriculum

The curriculum is aimed at satisfying the Chemistry requirement of the national policy on education originally prepared by Ministry of Education, Science, and Sports [MOESS], (2010). This curriculum according to Ministry of Education, Science, and Sports [MOESS], (2010) is intended to:

i. Create awareness of the interrelationship between chemistry and the other disciplines or careers.

ii. Provide knowledge, understanding and appreciation of the scientific methods, their potential and limitations.

iii. Create awareness that chemical reactions and their applications have significant implications for society and the environment.

iv. Develop the ability to relate chemistry in school to the chemistry in modern and traditional industries or real world situations.

v. Use facts, patterns, concepts and principles to solve personal, social and environmental problems.

vi. Use appropriate numeric, symbolic, nomenclature and graphic modes of representation and appropriate units of measurement (e.g. SI units)

vii. Produce, analyse, interpret and evaluate qualitative and quantitative data; solve problems involving quantitative data; identify sources of error and suggest improvements to reduce the likelihood of error.

viii. Apply knowledge and understanding of safe laboratory practices and procedures when planning investigations by correctly interpreting hazard symbols; by using appropriate techniques for handling, maintaining and storing laboratory materials and by using appropriate personal protection equipment.

ix. Develop the ability to communicate ideas, plans, procedures, results, and conclusions of investigations orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats (e.g. data, tables, laboratory reports, presentations, debates, models)

The objectives are to be achieved in the three (3) years of Senior High School education. A total of six periods per week is allocated to the teaching of chemistry with each period consisting of forty minutes (Ministry of Education, Science, and Sports [MOESS], 2010).

Teachers are to ensure that students are adequately prepared before each practical class. Also teachers are to ensure that practical classes are started in the second year alongside the theory classes.

In addition to the above objectives, the WAEC syllabus in its objectives for Chemistry include to: enable students appreciate the scientific method which involves experimentation, accurate observation, recording, deduction and interpretation of scientific data; enable students to develop laboratory skills, including an awareness of hazards in the laboratory and safety measure required to prevent them (WAEC, 1998-2015).

To realize the above stated objectives, the senior high school chemistry curriculum content is organized around the major concepts of energy, periodicity and structure of the atom, acids, bases and salts, solubility. The curriculum also include: particulate nature of matter, periodicity, and chemical combination, quantitative aspects of chemical reaction, rate of reaction, equilibrium, carbon chemistry and industrial application of chemistry. The curriculum is thus carefully structured to meet with the objectives of chemistry education. The curriculum recommends that guided-discovery approach be used in teaching. It also recommends the following assessment instruments: multiple choice items, structured short answer questions, essay questions and rating scales (where necessary). The chemistry curriculum is laudable enough (Anaekwe, 1997), but the perennial poor achievement and interest (Ifeakor, 2006; Njoku, 2003) suggested poor implementation of the curriculum. There is therefore the need to explore cooperative learning approaches of which STAD is seen as the suitable student-centered on the students' achievement in titrimetric analysis, an important area of quantitative analysis in practical chemistry.

2.8 The classroom implementation of SHS chemistry curriculum

Chemistry teachers need to be equipped with appropriate skills, attitudes and competencies necessary for effective implementation of the subject's curriculum. They should also exhibit good mastery of content. This will enable them to demystify the subject's abstractness to students by helping them to link what is learnt in class with real life situations (Chepkorir, Cheptonui, & Chemutai, 2014). This helps the learners to appreciate the subject and see its relevance. Influence of physics teacher's qualifications and experience on learners' achievement in senior high school in Nigeria confirmed that, teacher quality has influence on students' achievement (Baubeng, Osei, & Ampia, 2014). In addition, wrong handling of practical by underqualified teachers lowers performance in chemistry.

Chemistry teachers need to attend workshops in order to sharpen their pedagogical capacities in conformity with the current trends in curriculum implementation.

2.9 Senior High School Chemistry Practical Activities

Instruction in chemistry is done through practical and theory work. Typically, the term practical mean experiences in school settings where students interact with materials to observe and understand the natural world. The practical are mainly done as student experiments in the laboratory and as teacher demonstrations either in laboratories or in classrooms, while the theory is often done in the classroom (Twoli, 2006). Wellington (1998) described chemistry practical as teacher demonstrations or as class experiments where all learners are on similar tasks, working in small groups or a circus of experiments with small groups of learners engaged in different activities, rotating in a carousel. In secondary schools, laboratory activities are designed and conducted to engage students individually, or in small groups (student experiments) and in large-group demonstration settings (teacher demonstrations) (Hofstein & Mamlok-Naaman, 2007). Successful learning of chemistry depends partly on correct use of a teaching method whose activities target most learning senses. Since chemistry is a subject that encourages "hands on" experiences, more practical oriented modes of instruction should be selected (Twoli, 2006).

Practical is a very prominent feature of school science in many countries and a high proportion of lesson time is given to it. Science practical is very much a characteristic of the school science curriculum. They have been part of school science curriculum for over a century, and their place in a chemistry lesson has often gone unquestioned (Bennet, 2003). For example, the West African Examinations Council (WAEC) syllabus had over the years recommended that the teaching of all science subjects listed in the syllabus should be practical - based, and after several decades of emphasizing the assumed importance of practical activities in science teaching and learning, the importance became elevated to the level of a dogma (Abimbola, 1994). Therefore, it is important to analyze the purposes related to laboratory work, as the purposes need to be well understood and defined by teachers and students alike for the chemistry practical to be effective. It is due to such concerns that this study is seeking to use STAD to improve the performance of students on titrimetric analyses a major area when it comes to practical in chemistry.

2.10 The Importance of Senior High School Chemistry Practical Activities and Skills Developed In Titrimetric Analysis

To date, many studies have been conducted on the importance of laboratory work while teaching science. Currently, science educators and teachers agree that laboratory work is indispensable to the understanding of science (Cardak, Onder, & Dikmenli, 2007; Tan, 2008). The role of laboratory work in science education has been detailed by some researchers (Lunetta, Hofstein, & Clough, 2007). The main purpose of laboratory work in science education is to provide students with conceptual and theoretical knowledge to help them learn scientific concepts, and through scientific methods, to understand the nature of science. Laboratory work also gives the students the opportunity to experience science by using scientific research procedures. In order to achieve meaningful learning, scientific theories and their application methods should be experienced by students. Moreover, laboratory work should encourage the development of analytical and critical thinking skills and encourage interest in science. Teaching and learning of science has over the years tried to mimic what "real" scientists do. The processes of science, the scientific method, the inquiry process, the content of science and the habits of scientists are all re-contextualized in the science curriculum for schools in many parts of the world (Ling & Towndrow, 2010).

There are two extreme thoughts regarding the importance of Chemistry laboratory experiments/practical (Achor, Kurumeh & Orokpo, 2012). The first one is that in traditional approaches, little opportunity is given to student initiatives or circumstance. In this approach, all the laboratory procedures are carefully listed in the provided manual, and frequently the student is simply asked to fill in a well-planned report template. At the end of a laboratory session, students have no real opportunity of understanding or learning the process of doing Chemistry. The second one is that a student is given an opportunity to engage in deep learning (Gunstone & Champagne, 1990). This would provide a student an opportunity in identifying the main objectives of the work and in planning and executing it, of identifying the conceptual and practical difficulties encountered, recording and discussing the results and observations and of suggesting practical alterations and improvements The latter, thus, could result in a significant positive impact on a students' ability to learn both the desired practical skills and also the underlying theory.

Chemistry is a practical oriented science subject. Chemistry presents students with abstract ideas. This is because it deals with invisible concepts such as atoms. The only way to remove the abstractness of these subjects is to give students experiences that can enhance their understanding of the subject. Most of these experiences are gained in titrimetric analysis process in the laboratory. Miller (2004) observed that abstract ideas cannot simply be transferred from teacher to students. The students must play an active role in appropriating these ideas and making personal sense of them. According to Hofstein (2004), laboratory activity (practical work) is contrived learning experiences in which students interact with materials to observe phenomena. These experiences may have different levels of structure specified by teachers or laboratory handbook (manuals) and may include phases of planning and design, analysis and interpretation as the central performance phase. According to Woolnough (1991), care should be taken because it is not just enough for students to do something in the laboratory but rather laboratory experiences need to be designed so that they focus attention. The laboratory gives the students appreciations of the spirit and the method of science, promotes problem solving, analytic and generalization ability, provide the students with some understanding of the nature of science. Woolnough (1991) stressed that if we want students to acquire skills that are used by practicing scientists and if we are concerned with the teaching of the process skills of science, practical work seems to be vital in this context. In a laboratory work of a titrimetric analysis class, numerous experiences may be provided in which students manipulate materials, gather data, make inferences and communicate the results in a variety of ways. According to Hofstein (2004), practical activities are central in science teaching. They enhance the achievement of objectives of science education (cognitive, psychomotor and affective). In titrimetric analyses, practical skills are gained and are often tested in chemistry paper three. The paper tests students'

- Ability to follow a set of instructions
- Manipulative skills such as the ability to handle apparatus.

- Ability to make accurate observations
- Ability to record observations accurately
- Ability to make accurate deductions. (WAEC, 2013-2017)

According to Hofstein (2004), practical work enhances learning by allowing students to work together in groups hence discussing among themselves in a language familiar to all. This the researcher believed could be done through STAD.

Most of the laboratory skills developed in titrimetric analyses in chemistry are the same as those taught in science education. According to Twoli (2006), skills taught in the chemistry laboratory are practical skills. The skills are of two types namely; manipulative skills and process skills.

2.12 Manipulative Skills

Manipulative skills are also known as motor skills. The skills deal with the ability to handle and arrange apparatus and materials for proper experimentation (Twoli, 2006). If students have proper manipulative skills, they would make accurate observations and record the data collected accurately. This would then translate to accurate interpretation. Manipulative skills include handling, arranging, fixing, pouring, heating, filtering and weighing.

2.13 Process Skills

The science process skills are tools that students use to investigate the world around them and to construct science concepts, (Yockey, 2001). They are a means to learning and are essential to the conduct of science. Process skills are more cognitive in nature, (Twoli, 2006). Yockey (2001) gave the following as the main process skills which should be emphasized in any science practical session. They include; observing, classifying, measuring, communicating, inferring, predicting, interpreting, experimenting skills, comparing, contrasting, organizing and analyzing. The skills are not just useful in science and titrimetric analyses but in any situation that requires critical thinking. The process skills are integrated together when scientists design and carry out experiments or in everyday life when we all carry out fair test experiments. All the skills are important individually as well as when they are integrated together.

2.14 Action Research and Case Study

2.15 Action Research

In this study, action research approach was adopted. Action research approach is a process in which participants examine their own educational practice systematically and carefully, using the techniques of research (Ferrance, 2000). As a method of research, action research has a wide scope. It covers an impressive range of setting such as people's lives, disadvantage groups, employment problems, training needs of people and many more. All these factors concern problems of humans which are crying for solutions. Again according to Hanson (2017), action research was associated with a cyclic nature and allowed both researchers and participants to continually learn from each other. This provides opportunity for continuous reflection as it fosters deeper understanding of a situation with conceptualization and moves through several interventions and evaluation phases. Action research may be taken by any person or group of persons (Cohen, Manion & Morrison, 2007). These may be teacher's students, social workers, university departments, research institution departments or any interested groups. Cohen, Manion and Morrison (2007) classified action research to be used in areas such as:

- *Teaching methods*: replacing a traditional method by a discovery method
- Learning strategies: adopting an integrated approach to learning in preference to a single- subject style of teaching and learning.
- *Evaluative procedure*: improving one's methods of continuous assessment.
- *Attitudes and values*: Encouraging more positive attitudes to work, or modifying pupil's value systems with regards to some aspect of life.
- *Continuing professional development of teachers*: improving teaching skills, developing new methods of learning, increasing powers of analysis, of heightening self- awareness.
- *Management and control*: the gradual introduction of the techniques of behavior modification.
- *Administration*: increasing the efficiency of some aspect of the administrative side of school.

Action research may be considered as a research that has the aim of closing up gaps between research and practice (Cohen, Manion & Morrison, 2007). This is due to the fact that though research has traditionally sought to solve problems of society people have accused research of not impacting practice and solving human problems.

2.16 Characteristics of Action Research

- ❖ It is diagnostic, activity-oriented and reflective. This implies that action research is used to diagnose problems, to carry out activities and may be used to reflect on one's practices and includes reflection
- ❖ It brings about improvement, innovation, development of social practice and gives better understanding to researchers about what they are investigating.
- ❖ It allows for practical problem solving.
- ❖ I helps to expands one's scientific knowledge.

- It uses its findings to reformulate problems for investigation
- It seeks understanding of social issues of processes of change in social systems.
- It takes into account views of all participants so it's participatory.
- It is flexible in interpretation of its findings as no single authoritative interpretations are allowed.
- It allows researchers to develop self-criticism with the aim of gaining more knowledge from research.

2.17 Procedure for Action Research

According to Cohen, Manion and Morrison (2007) in planning to carry out action research one has to take cognizance of the following steps:

- Identification of the present situation or practice which you wish to change.
- Devise a procedure for solving the problem and carry it out
- Follow your procedure to determine your findings and reflect on them
- If necessary, modify your procedure in relation to your findings and continue with the research.
- The process may continue until you satisfied with your findings.

From the above procedure it is clear that action research may require repetition of the research by going through a number of cycles in order to reach the final findings.

2.16 Case Study

This involves collecting data, generally from only one or a small number of cases. It usually provides rich detail about those cases of a predominantly qualitative nature.

Case studies focus on one (or just a few) instances of a particular phenomenon with a view to providing an in-depth account of events, relationships, experiences or processes occurring in that particular instance (Denscombe, 2010). According to Yin (2003), a case study design should be considered if: the focus of the study is to answer "how" and "why" questions; you cannot manipulate the behaviour of those involved in the study; if you want to cover contextual conditions because you believe they are relevant to the phenomenon under study; or the boundaries are not clear between the phenomenon and context. Case study method enables a researcher to closely examine the data within a specific context. In most cases, a case study method selects a small geographical area or a very limited number of individuals as the subjects of study.

The greatest strength of case study is that it allows the researcher to concentrate on a specific instance or situation and to identify, the various interactive processes at work. These processes may remain hidden in a large scale survey but may be crucial to the success or failure of the study. This was explained by Yin (2003), as an in-depth study of a particular research problem rather than a sweeping statistical survey. A key strength of case study method involves using multiple sources and techniques in the data gathering process.

2.17.1 The Nature of cooperative learning

Cooperative learning is one of teaching method which is commonly used in the process of teaching and learning. Cooperative learning puts forward learners' interactions and active participation instead of passive listening in the classroom. Cooperation offers students' interaction and it is student – centered. In cooperating learning students must exchange their knowledge and opinion. Cooperation is working together to accomplish shared goals. Within cooperative activities individuals seek outcomes that are beneficial to themselves and beneficial to all other group members.

According to Slavin (1996), cooperative learning refers to instructional methods in which students work together in a small group to help each other to learn. A similar definition is also proposed by Martins-Umeh (2009) who stated that cooperative learning as an approach to teaching that makes maximum use of cooperative activities involving small groups of learners in the classroom. They are a team whose players must work together in order to achieve goals successfully. Khan (2011).stated that research on cooperative learning has established that these strategy can be very effective in increasing student achievement in many subjects and grade levels when students groups are rewarded on the basis of the average learning of the groups' member.

Again, Anaekwe (2006).stated about cooperating learning as below: "Cooperative learning is group learning activity organized so that learning is dependent on the social structured exchange of information among learners in groups and in which each learner is held accountable for his or her own learning and it motivated to increase the learning of others". It means that cooperative learning is one of effective teaching method in which small teams, each with students of different levels of ability, use a variety of learning activities to improve student's achievement in many subjects and grade levels. Each member of a team is responsible not only for learning what is taught but also for helping team mates learn, thus creating an atmosphere of achievement. Student work through the assignment until all group members successfully understand and complete it. Cooperative learning also can motivate to increase each other's learning and to maximize students' involvement, participations and cooperative activities.

2.17.2 Theory of Cooperative Learning.

The word cooperative learning emphasizes another important dimension of cooperative learning. It seeks to develop classroom that foster cooperation rather than competition in learning.

2.17.3 The Characteristics of Cooperative Learning

From the forgone definition, it can be concluded that cooperative learning has its own characteristics. According to Anaekwe (2006), the characteristics of cooperative are as follows:

- Uses small groups of three or four students
- Requires group cooperation and interaction
- Focuses on tasks to be accomplished
- Mandates individual responsibility to learn
- Supports division of labour.
- Students work in teams to master learning goals
- Teams are made up of high, average and low – achieving student
- Whenever possible, teams include a radical, cultural and gender mix.
- Reward systems are oriented to the group as well the individual.

2.17.4 The Advantages and Disadvantages of Cooperative Learning.

Anaekwe (2006) listed some of the merits of using cooperative learning strategy in science, mathematics and technology as follows:

- Enhances students' achievement and interest in learning concepts;
- It promotes group cohesion, peer-support, learning interdependence, self-esteem;
- It enables non-mainstreamed student to accept their mainstreamed classmates, thereby erasing petty jealousy among bright and dull students;

- Cooperative efforts result in participants striving for mutual benefit so that all group members: Gain from each other's effort;
- Recognize that all group members share a common fate;
- Know that one's performance is mutually caused by oneself and one's team members;

However, cooperative methods was warned to be used cautiously because of the following demerits: cooperative learning may hinder the pace with which bright student masters concepts while he is helping the dull group members (Cohen, Broody, & Sapon-Shevin, 2004). Again, a loquacious student may dominate one who is reticent, and some students will naturally prefer to work on their own and may not enter freely into cooperative interaction. It is therefore warned that cooperative learning may not be appropriate all the time as an instructional approach.

Therefore, an effective Chemistry teacher needs to be eclectic in his or her choice of instructional approach. Cooperative learning therefore is an innovative instructional approach, which is capable of solving some instructional problems if carefully employed. Since difficult concepts in Chemistry have shown strong resistance to the conventional instructional approaches, this study deemed it necessary to use STAD a type of cooperative learning approach to improve the performance of students in titrimetric analysis.

2.17.5 Kinds of cooperative learning.

Anaekwe (2006) differentiated cooperative learning into two kinds, namely formal and informal cooperative learning.

These are:

1. Formal Cooperative Learning

These strategies focus more on teacher-led instruction and a certain amount of students' competition, usually between cooperative groups rather than between individual students.

The examples of formal cooperative learning strategies are:

a. Students Teams – Achievement Divisions (STAD)
b. Teams – Geams- Tournament (TGT)
c. Jigsaw

2. Informal Cooperative Learning

It occurs when the teacher asks question and the students discuss among themselves or with the teacher and provide a summarized or synthesized response.

The examples of informal cooperative learning strategies are:

a. Numbered Heads Together
b. Think – pair – share
c. Think – pair – square

2.18.1 The Nature of the STAD

Student Team – Achievement Division (STAD) is one of the simplest and most straight forward of the cooperative learning approaches (Anto, Padmadewi, & Putra, 2013). Slavin (1996) also stated that (STAD) is one of the simplest of all cooperative learning method, and is a good model to begin with for teachers who are new to cooperative approach.

STAD Team membership consists of four students, based on the heterogeneous abilities (Anto, Padmadewi, & Putra, 2013). The teachers present the lesson to the whole group in one or two sessions, and the class divides into teams for mastery. Students who have mastered the material help slower teammates. Practice is stressed in discussion and questioning. Class quizzes are frequent, and student scores are averaged into a team scored to ensure cooperation and assistance within groups. Quizzes are scored in terms of progress so that slow performing groups have the opportunity to gain recognition and improve. Team rewards are given based on the performance of their team as a "good", "great" or "super" teams to give students an opportunity to work with other students and give members the low – scoring teams a new chance.

The main idea behind STAD is to motivate students, to encourage, and improve each other's skills presented by the teacher. If the students want their team to get team rewards, they must help their teammates to learn the material, they must encourage their teammates to do their best, and express the atmosphere that learning is important, valuable and fun.

2.18.2 Components of STAD

According to Slavin (1996), students Teams – Achievement Division (STAD) consists of five major components, as follows:

1. Class Presentation:

The teacher presents the material to the whole group using verbal presentation or text. Materials in STAD's are initially introduced in a class presentation. Class presentations in STAD differ from the usual class teaching, only in that, they must be clearly focused on the STAD unit. In this way, students realize they must pay careful attention during the class presentation, because doing so would help them do well in the quizzes, since their quiz scores determine their team's scores.

2. Teams Study

Students are assigned to four or five member learning teams. The team members should represent a cross section of the class in terms of academic performance, gender and ethnicity. Team members work together to study worksheets or other study devices to master the academic material, which consist of problems and information to be mastered. Then help each other learn the material on team discussions.

The major function of the team is to make sure that all the team members are learning, and more specifically to prepare its members to do well in the quizzes. After the teacher presents the material, the team meets to study worksheets or other materials. Most often, the study involves students discussing problems together, comparing answers and correcting any misconceptions if teammates make mistakes.

3. Quizzes

After the team practices, the students assess individual quizzes that include many of questions that the students may not help one another during quizzes.

4. Individual Improvement Scores

The idea behind the individual improvement scores is to give each student a performance goal that can be attained if he or she works harder than in the past. Any student can contribute maximum points to his or her team in this scoring system, but no student can do so without doing his or her best work. Each student is given a “base” score, derived from the student’s average past performance in similar quizzes. Students that earn more points for their teams based on the degree to which their quiz scores exceed their base scores.

5. Team Recognition

Certificates or rewards are given to groups whose average scores on the test are higher than their base scores. Team reward are given based on their team as a "good", a "great" or "super" team (Anto, Padmadewi, & Putra, 2013).

2.18.3 The Preparation of Student- Team- Achievement Division (STAD)

The preparation of applying STAD by Slavin (1996) mentioned the steps prepared by the teacher before the implementation of STAD as follows;

a. Material

Materials can be made by the teacher by adapting from textbooks or other relevant published sources. It covers lesson plan, a worksheet, answer sheet, and a quiz for each unit of lesson plan.

b. Assigning students to team

Students are assigned four or five member team. The four persons in each team in the class must represent different background, such as; sex, performance (high performer, average performer, and low performer). The teacher does not let students choose their own teams, because they would tend to choose others like themselves. Their achievement level bases on the students' pre-intervention test scores.

c. Determining Initial Base Scores

It can be done by using the students' average scores in past quizzes or by using the students' final grades from the previous year test.

d. Team Building

Before starting any cooperative program, it is a good idea to start off with one or more team-building exercises just to give a team logo, banner and song.

4. Schedule of Activities

According to slavin (1996), STAD consists of a regular cycle of instructional activities, as follows:

1. Teach

The teaching learning process in Student Team-Achievement Division begins with a class presentation. The presentation should cover the opening, development and guided practice components of the total lesson.

2. Team Study

During team study, the students work on worksheets in their teams to master the material presented by the teacher. Only two copies of the worksheets and answer sheets are given to each team, this forces teammate to work together. Before beginning team work, students discuss the following team rules;

a. Students have a responsibility to make sure their teammates have learned the materials.

b. No one finishes studying until all teammates have mastered the subject.

c. Ask all teammate for help before asking the teacher.

d. Teammate may talk to each other softly.

3. Test

Students take individual quizzes or other assessments. The teacher gives students adequate time to complete it. Do not let the students work together on the quiz; at this point they must show what they have learned as individuals.

4. Figuring Individual and Team Scores

As soon as possible after each quiz, the teacher should compute individual improvement scores and team scores. Team scores are computed on the basis of team members' improvement scores, recognizing high-scoring teams. If possible announce team scores in the first period after the quiz, to increase their motivation to do their best. There are three components which influence the scores:

a. Improvement Points

Students earn points for their teams based on the degree to which their quiz scores (percentage correct) exceed their base score. The purpose of base scores and improvement points is to make it possible for all students to get maximum points to their teams, whatever their level of past performance. Students understand that it is fair to compare each student with his or her own level of performance.

b. Recognizing Team Accomplishments

Three levels of rewards are given. These are based on average team scores.

2.18.4 The Rationale for using STAD for this study

Student Team-Achievement Division (STAD) is one of the techniques of cooperative learning and it is an appropriate way to improve titrimetric analysis. Based on the previous underlying theory, the researcher assumes that Student Team-Achievement Divisions (STAD) can be used as an effective technique to improve students' performance in titrimetric analyses. Student Team-Achievement Division (STAD) technique is a group learning model which emphasizes on group members' collaboration in mastering the materials. It is a small group consisting of four students with different background, sex, academic competence, and racial or ethnic groups.

There are several reasons why Student Team-Achievement Division (STAD) can improve students' performance in titrimetric analyses:

1. Student Team-Achievement Division (STAD) is one of the major approaches that is accepted as an effective technique of cooperative learning developed by Slavin (1997). This technique can be very effective in increasing students' achievement and students'

motivation in many subjects and grade levels when the students group are rewarded on the basis of the average learning of the groups' member.

2. Student Team-Achievement Division (STAD) also refers to a technique of instruction whereby student work together in groups to reach common goals. Thus, the group has responsibility in tutoring their members, and sharing knowledge with each other. By using Student Teams-Achievement Divisions (STAD), students benefit from sharing ideas rather than working alone. Students have to help one another to learn in order to reach the goal. So the students do not only learn from the teacher but also learn from their friend.

3. Student Team-Achievement Division (STAD) emphasizes on mastering the materials through student-centred in which students are active and teacher is a facilitator who guides students. Student-centred means that, the students mostly dominate the class by producing a productive talk to their teammates' opinions. The group members should be active in doing the activity, such as: helping each other, communicative interactions between students or sharing knowledge and opinion.

4. The concept is team reward, the team will get a certificate or other awards, if they managed to exceed certain predetermined criteria. Teams do not compete to earn scarce rewards.

5. It is individual accountability. Individual accountability means that the team's success depends on the individual learning of all team members. Accountability focused on the activities of the team members in helping each other to learn and make sure that everyone in the team is ready for quiz or other forms of assessment of the student without the helping each other.

6. There is an equal opportunity for success means that all students contribute to the team by improving their own past performance. This ensures that student with high,

medium and low achievements are challenged to do their best and that the contribution of all team members are valued. Above all, the use of STAD for this study will help:

1. To motivate the students in order to support and assist each other in mastering the skills taught by the teacher.

2. Give the responsibility to the students individually or in groups

3. Develop cooperative learning would form or guide the attitudes of students in order to form the ideal behaviour in social life.

4. Increase empathy among students through communication and interaction with other groups.

5. Train the students' ability to argue

6. Low-ability students to improve their abilities.

7. Encourage them to do their best and revive a norm that learning is important, valuable.

2.19 Gender and Performance in Senior High School Practical Chemistry

Gender is a concept that refers to the social and cultural constructs that each society assigns to behaviours, characteristics and values attributed to men and women (Duyilemi, 2005). Gender is any physical and behavioural difference between males and females which are social culturally based (Ezeh, 2013). Thus gender deals with socially defined sex roles, attitudes and values which were acquired through socialization and ascribed by a given community as appropriate for one sex or another. It affects power sharing, decision making and division of labour. Gender and its manifestation in various human activities appears to be a strong predictor of human conduct. Science subjects such as chemistry are given masculine outlook by many educationists (Ogunleye & Babajide, 2011). Gender is implicated in students' achievement in science (Ogunleye & Babajide, 2011). The issue of gender and gender stereotyping permeate every aspect of human endeavour.

This affirmed why Jegede (2007) observed that the female students show higher anxiety towards carrying out volumetric analysis (acid base titration) in senior secondary schools than male students. Ssempala (2005) reported that there exists disparity in male-female performance in sciences. This corroborates why Umoh (2003) stated that more difficult works are usually reserved for males while the females are considered feminine in a natural setting. Thus in schools, males are more likely to take to difficult subject areas like science (chemistry) while the females take to career that will not conflict with marriage chances. Again, Aina (2012) noted that a wide gap exist between the girl child and the boy child going to school and this also brings disparity in the courses they offer in school. According to him females mind were tailored towards economically viable courses leaving such courses like engineering, medicine, mathematics etc. to men. Bosede (2010) stated that gender influences students' academic performance in volumetric analyses. Therefore, gender seems to contribute to differences in students' performance in science subjects such as chemistry. Consequently, men are assumed to be better equipped to pursue science related courses compared to women, creating greater obstacles for students in acquiring science process skills in volumetric analyses. As to whether any cooperative teaching technique such as STAD would favour the female is another question this research would like to answer. Again, it becomes necessary to address the issue of gender stereotype in volumetric analyses irrespective of school location.

2.20 The Empirical Review

Some studies related to the implementation of Students Team Achievement Divisions (STAD) technique proved that STAD can be used to improve students' knowledge in many subject areas. Among which, there are six studies that the writer considerer as a basic consideration in holding a research. The first is the research conducted with the title ―The Effect of STAD Technique and Learning Motivation toward the Students' Reading Competence (Anto, Padmadewi, & Putra, 2013). The researchers identified the effect of the implementation of STAD technique and learning motivation toward students' reading competence of the eight year students of SMP N 3 Ubud. The result of this research is there was 7.06 % difference and it can be concluded that the difference was statistically significant. It could be said that teaching reading comprehension using STAD is more effective than using conventional teaching method. The relationship between this research and the writer‟s research was they used STAD technique and reading comprehension as variables. However, the writer in this study has focused on the use STAD to improve the performance of students on titrimetric analysis. Also whiles Anto, Padmadewi, and Putra conducted the research on eight year students this research is focus on senior high school students.

Another previous study related to the research is from Alireza (2009) with his paper research entitled ―The Effect of Cooperative Learning Technique on College Students' Reading Comprehension. Alireza (2009) investigated the impact of Students Team Achievement Division (STAD) and Group Investigation (GI), which were two techniques of Cooperative learning, on students' reading comprehension achievement. The result of his research revealed that STAD was a more effective technique in improving reading comprehension achievement whereas traditional teaching did not enhance reading comprehension significantly. According to Alireza, team rewards, as one of the central concepts of STAD, may have a strong impact on learners' performance in reading comprehension. The relationship between this research and the writer's research was the use of variable, STAD. It was identified as Learning Technique on College Students' Reading Comprehension, however in this study STAD was chosen as a determined technique to improve the performance of student in senior high school student on titrimetric analysis.

The third previous study was from Glomo-Narzoles (2015) study the title of which was "The Implementation of The Cooperative Learning method in Teaching Reading Comprehension". The research was conducted to find out whether or not cooperative learning improved students' reading comprehension. The design employed in this research was a case study using Classroom Action Research approach. The findings of the study showed that cooperative learning method (STAD and Jigsaw) improved the students' comprehension in reading descriptive text. This research is in line with the writer's research in research design. However, the writer in this study has different focus. The writer focuses on STAD technique, one of the types of cooperative learning method.

The fourth study was conducted was entitled *Effects of Student Teams-Achievement Divisions Strategy and Mathematics Knowledge on Learning Outcomes in Chemical Kinetics* (Adesoji & Ibraheem, 2009). This study was implemented to senior secondary school in Epe division of Lagos State, Nigeria. Though the study also used senior high school students as the participants, the objective of this study was to investigate the effects of Student Achievement Division and mathematics ability to find out the outcomes in learning chemical kinetics.

The fifth was a research conducted by Kusi (2013) - Improving the performance of students' in titrimetry through cooperative learning in senior high schools within

Kumasi. The study was conducted to find out whether there was significant difference between students who were taught by cooperative learning technique and those who were taught without the cooperative learning technique in titrimetry. However this study was designed to improve the performance of students in titrimeric analysis using STAD.

Although studies have been conducted into aspects of the teaching and learning of some concepts in English Language, Mathematics, Chemistry and some other subject areas using cooperative learning and other strategies such as the STAD, no study to that effect has been conducted in the area of this study using the STAD. Above all, most of these studies have their strengths and weakness. For this reason, this study has focused on the use of STAD to improve the performance of students on titrimetric analysis which has not been studied so far.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Overview

The chapter includes the research design adopted for the study, the study area, the study population, sample and sampling techniques and research instruments used to collect the data. The reliability of the main instruments, validity of the main instruments, interventions, data collection procedures and data analysis procedure were also discussed in this chapter.

3.1 Research Design

The research design for this study was a case study design using the action research approach. According to Denscombe (2010), research design establishes how a research project is conducted. Again, a research design is the logic that links the data to be collected and the conclusions to be drawn to the initial questions of a study; it ensures coherence (Amedahe, 2002). Research design is a plan or blue-print that specifies how data relating to a given problem should be collected and analysed (Amedahe, 2002). The researcher further explained that for every research study, the choice of a particular research design must be appropriate to the subject under investigation, and that the various designs in research have specific advantages and disadvantages. Therefore, a case study design, with an action research approach was adopted for this study as it sought to improve on a situation that affected a whole class in a dynamic and collaborative manner.

Case study involves collecting data, generally from only one or a small number of cases. It usually provides rich detail about those cases of a predominantly qualitative nature.

According to Yin (2003), a case study design should be considered if: the focus of the study is to answer "how" and "why" questions; you cannot manipulate the behaviour of those involved in the study; if you want to cover contextual conditions because you believe they are relevant to the phenomenon under study; or the boundaries are not clear between the phenomenon and context.

Action research approach involves systematic observations and data collection which can be used by practitioner researcher in reflection, decision making and development of more effective classroom strategies (Parson & Brown, 2002). Although there are many types of research that may be undertaken, action research specifically refers to a disciplined inquiry done by a teacher with the intent that the research would inform and change his or her practices in the future. The researcher also employed triangulation which is a mixed method approach where both qualitative and quantitative methods of inquiry are used to collect data. Triangulation may be defined as the use of two or more methods of data collection in the study of some aspect of human behaviour (Cohen, Manion & Morrison, 2007). The triangular techniques attempt to map out, or explain more fully, the richness and complexity of human behaviour by studying it from more than one standpoint through the use of both quantitative and qualitative data (Cohen, Manion & Morrison, 2007).

Qualitative method is used to understand, in depth, the viewpoint of research participants concerning the difficulties they faced doing a task since qualitative research is more descriptive than predictive (Cohen, Manion & Morrison, 2007). Qualitative methods provide a holistic description of the phenomena under study. It could also be used to describe data numerically and answer the specific questions or hypothesis raised.

3.2 The Study Area

The study was conducted at the Breman Asikuma SHS in Breman Asikuma Odoben Brakwa District of Central Region. The school was jointly established by the Breman Traditional Council and Methodist Church in 1964 but was fully absorbed by the Government of Ghana eight years later with boarding facilities. Farming and trading are the most pre-dominant economic activities in the area.

3.3.0 Population

Population is a group of individuals or objects who have the same characteristics (Creswell, 2012). He further explained that a population defines the limits within which research findings are applicable and that a population could be large or small and a researcher needs to decide what group to use for the study.

3.3.1 Target Population

The target population refers to the entire group of individuals to which researchers are interested in generalizing their conclusions (Castillo, 2009). The target population contains members of a group that a researcher is interested in studying. The results of the study are generalized to this population, because they all have significant traits in common. The target population usually has varying characteristics and it is also known as the theoretical population. In this study, the target population comprised all form two chemistry students in Breman Asikuma Senior High School.

3.3.2 Accessible population

Accessible population is the population which the researchers can readily access, work with, and apply their conclusions (Castillo, 2009). It is also the portion of the population to which the researcher has reasonable access. Accessible population is the subset of the target population. Accessible population is also known as the study population. It is from the accessible population that researchers draw their samples.

In this case, the accessible population was all form two science students of Breman Asikuma Senior High School. This school was selected due to its proximity to the researcher. The researcher has been teaching in the school for the past seven years. The choice of form two science students was also made because they had been exposed to prerequisite concepts in titrimetric analysis in the first year and had attained some level of maturity and confidence needed. Again, the choice of form two science students was also due to the fact that their final WASSCE examination is in their next year.

3.3.3 Sample

A sample is a smaller group which is drawn from a larger population and studied (Punch, 2006). Again, a sample is any group on which information is obtained for study (Fraenkel & Wallen (2000). A sample is representative of the population to the extent that it exhibits the same distribution of characteristics as the population. The concept of sample arises from the inability of the researchers to test all the individuals in a given population. The sample must be a fair representative of the population from which it was drawn and it must have good size to warrant statistical analysis (Castillo, 2009).

3.3.4 Sampling Procedures

Sampling is the process of selecting units (e.g., people, organizations) from a population of interest so that by studying the sample one may fairly generalize results back to the population from which they were chosen (Trochim, 2006). This indicates the systematic selection of a limited number of elements (persons, objects or events) out of a theoretically specified population. Sampling, according to Amoani (2005), is the procedure whereby elements or people are chosen from a population to represent the characteristics of that population. Trochim (2006) pointed out that there are two main types of sampling: probability and non-probability samples. Probability sampling represents a group of sampling techniques that help researchers to select units from a population that they are interested in studying. Collectively, these units form the sample that the researcher studies. A core characteristic of probability sampling techniques is that units are selected from the population at random using probabilistic methods. Some of the probability samples are simple random, systematic and stratified sample.

The researcher adopted non-probability sampling techniques to select the sample. Participants in this sampling technique were selected based on characteristics they possess or their availability to participate (Cohen, Manion & Morrison, 2007). The researcher used this technique to select participants because participants under this technique should meet pre - established criteria. Non-probability sample is a deliberately selected sample to represent the wider population; it seeks only to present a particular group, a particular named section of a wider population, such as a class of students, a group of students who are taking a particular examination, and a group of teachers. Non-probability sampling represents a group of sampling techniques that help researchers to select units from a population that they are interested in studying. Collectively, these units form the sample that the researcher studies. A core characteristic of non-probability sampling techniques is that, samples are selected based on the subjective judgment of the researcher, rather than random selection (i.e., probabilistic methods), which is the cornerstone of probability sampling techniques. There are several types of non-probability sample: convenience sample, quota sample, snowball sample and purposive sample (Cohen, Manion & Morrison, 2007). Purposive sampling is the selection of sample on the basis of their judgment of their typicality or possession of the particular characteristics being sought Cohen, Manion, & Morison, 2007). That is, purposive sampling is done for those who have in-depth knowledge about the issue and by virtue of their experience. Patton (2002) said this type of sample focuses on selecting information-rich participants whose study illuminates the questions under study. It is also considerably less expensive to use such participants and is perfectly adequate since the findings would not be generalized beyond the sample.

This study therefore adopted purposive sample type to select the two intact classes of form two science students in Breman Asikuma Senior High School totaling ninety-five (95) for the study. They were made up of fifty- five (55) males and forty (40) female. These selected participants were easily and readily available, and have met the pre-established criteria for the study. Also they were chosen because of their familiarity and accessibility to the researcher. Rich information about the class performance and achievement were also readily available for the study. The students were also students who studied titrimetric analysis in chemistry for more than a year but have underperformed.

3.4 Research Instrument

Instruments employed for data collection were pre-intervention test, post-intervention test, interview and questionnaires, which were attitude-based for students. Students' conceptions and performance were gathered through the intervention tests. Interviews were also employed to assess students' true impressions about the difficulties of the titrimetric analyses (Appendix D). This is because written texts (tests and questionnaires) show mute evidence from participants and could be interpreted wrongly. According to Hanson (2017) interviews truly express participants' sentiments. The interview was also used to triangulate obtained data from tests and questionnaires and to corroborate them. The semi-structured interview sessions were audio recorded and transcribed. The interview schedule is presented as Appendix D.

A research instrument is a device used to collect data to answer the research questions. Data collection is an essential component in conducting research. O'Leary (2004), remarked that "collecting credible data is a tough task, and it is worth remembering that one method of data collection is not inherently better than another". Therefore, the data collection method use would depend upon the research goals, and the advantages and disadvantages of each method. He again emphasized that research instruments are tools used to collect data to answer the research questions. There are various research instruments for data collection. Zohrabi (2013) identified questionnaires, interviews, classroom observations and tests as some of the procedures for data collection. Some of the research instruments used by the researcher were discussed below.

3.4.1 Achievement Tests

The achievement tests consisted of test items based on the SHS chemistry syllabus and compared to standardised questions on the titrimetric analysis set by the WAEC for the West African Secondary School Certificate Examinations (WASSCE).

Test 1 which was made up of four sections (A-E) altogether was administered to the students before the intervention activities as a diagnostic test and same test 1 named as test 2 was administered to them as post-intervention test to determine the effectiveness of the intervention.

The first section, which was A, contained 4 test items that required the students to explain some terminologies associated with acid-base titration. In section B, the two test items required the students to answer questions on acid – base indicators. Section C contained 4 test items on skills acquisition on titration / titrimetric / quantitative process. Section D was made up of two test items that required the students to balance chemical equations correctly. One major test item in section E required students to record in a titration table and calculate average titre, it also required the students to calculate the concentrations of some analytes in mol/dm^3, g/dm^3 after acid-base titration. Each test covered such areas of titrimetric analysis and was administered for duration of 60 minutes. See Appendix A and B for the pre-intervention test and post-intervention test respectively. Answers of students to questions of both tests were marked using a marking scheme that the researcher prepared. See Appendix C for the marking scheme of pre-intervention test and post-intervention test. Each test was scored for 50 marks.

3.4.2 Interviews

An interview involves posing questions to respondents for answers in a face-to-face situation or by phone (Amedahe, 2002). According to him, there are many types of interviews, each of which differs from the others in structure, purpose, role of the interviewer, number of respondents involved in each interview, and form and frequency of administration.

The researcher conducted an informal interview with one student at a time after the pre-intervention test (Appendix D). A week after the test scripts had been scored; the researcher conducted an informal interview with fifteen (15) selected students who were also involved in the study. The selection was based on their respective scores in the achievement test. This was in the form of oral questionnaire and the needed information was given orally and face-to-face. This enabled the researcher to find out the students' reasons for supplying such answers to the test items.

3.4.3 Questionnaire

Questionnaires are straight forward written questions which require an answer by ticking the appropriate box; an efficient ways of collecting facts (Hannan, 2007). The respondents could also be provided with spaces in which they formulate their own responses. The questionnaire was a researcher designed one to elicit information from the students on the use of the STAD in teaching titrimetric analysis. Both closed and open-ended questions were used (Appendix E (a) and Appendix (b). The thirteen (13) closed-ended items with their associated Likert scales were used to find out specific responses. The Likert-type scales were used because the scales are often observed to provide data with relatively high reliability (Gabel, 1999). The last four (4) items were meant for the students to express themselves freely to bring out what the closed-ended aspect of the questionnaire could not provide.

3.4.4 Validity of the Main Instrument

Validity of the research instrument is the ability of an instrument to measure what it is designed to measure. An instrument is considered valid when there is confidence that it measures what it is intended to measure in a given situation (Punch, 2006). Also, the judgment that an instrument is measuring what it is supposed to is primarily based upon the logical link between the questions and the objectives of the study (Cohen, Manion & Morrison, 2008).

In order to validate the research instruments, the researcher consulted the SHS syllabus, prescribed texts, past internal and external national practical examination questions in chemistry for students. The purpose was to gain insight into what learners were expected to conceptualize, in order to develop the instruments accordingly. They were later cross checked by colleagues for content and construct validities and improved upon.

The researcher consulted his supervisor, departmental lecturers and other science education experts after constructing the test items, in verifying construct and content validity of the questionnaires. The supervisor, departmental lecturers and the science education experts assessed the relevance of the content used in the research instruments and necessary cancelations and modifications were made on some of the test items based on their feedback. Content validity of research instruments should be judged by the researcher and experts in the field (Cohen, Manion & Morrison, 2008). To further establish face and content validity of the research instruments, the researcher carried out a pilot study. The pilot study tested data collection and analysis procedures, clarity of the responses and the research assistants and ensured that the research instruments were not only valid but captured the required data. Again, the validity is used to assess how well a measure is able to provide information to help improve the study. It can also be used to predict future or current performance. Thus, it correlates test results with another criterion of interest. If the results of a study are not deemed to be valid, then they are meaningless to the study. If it does not measure what we want it to measure, then the results cannot be used to answer the research questions, which is the main aim of the study. These results cannot be used to generalize any findings and become a waste of time and effort. It is important to remember that just because a study is valid in one instance; it does not mean that it is valid for measuring something else.

3.4.5 Reliability of the Main Instrument

Reliability is the degree to which an assessment tool produces stable and consistent results. Reliability of any instrument is very important because, it concerns the degree to which an experiment, test or any measuring procedure yield the same results on repeated trials. The reliability of the main instrument was determined using Pearson's test-retest correlation coefficient. This idea was also confirmed with the fact that, test conducted at two different times could be used to determine the consistency of which answered questionnaire or test items or individual scores could remain relatively the same (stability of instrument) (Cohen, Manion & Morrison, 2008). To determine the coefficient of reliability of the instruments the tests items were pilot tested on twenty-eight (28) General Agriculture Science 2AG students of same characteristics in the school. The results of the pilot test were used to calculate the reliability coefficient.

Again, if the measurement results are to be used for making a decision about a group or for research purposes, or if an erroneous initial decision can be easily corrected, then the scores with modest reliability coefficients in the range 0.50 to 0.70 might be acceptable (Cohen, Manion & Morrison, 2008). The Pearson reliability coefficient for the pilot tests (test 1 and test 2) using excel 2010 was approximately 0.70. However the open- ended items in the questionnaire were used as a means through which the respondents expressed themselves freely on the use of the STAD. The free expressions give a balance picture of the situations. These expressions were put into themes for purposes of triangulation which helped to crosscheck the authenticity of the data collected using closed-ended questions as revealed by Punch (2006).

3.4.6 Pilot Study

The pilot study tested data collection and analysis procedures, clarity of the responses and ensured that, the research instruments were not only valid but captured the required data. Before the commencement of the main stages of data collection, a pilot study was conducted. This involved every aspect of the research such as instruments, interventions, and data collection -procedures. The result was used for reconstruction of some of the test items and correction of some lapses in the interventions and data collection processes. To avoid contamination, fifteen (15) second year Agriculture science students of same characteristics in the school were used.

3.8 Data Collection Procedures

The researcher collected data in three stages, namely: pre-intervention stage, intervention stage and post-intervention stage. Based on the model of research, the procedures was composed of cycles, in which the cycles consisted of four steps, these were planning, implementing, observing, and reflecting on the action. This steps were completed by revising of the action. The procedures of action research in this research are as follows under the three major stages:

3.8.1 Pre-intervention stage (Identifying the Problem)

Before planning the action, the researcher identified the problem that was faced by the students. In identifying problems, the researcher used interview, questionnaire and test.

a. Interview

The interview was held in order to identify the students' opinion and difficulties about the titrimetric analysis in a practical class and to know the problems faced by the students during teaching-learning process before using the STAD.

b. Questionnaire

Questionnaire (Appendix E) was given by the researcher after the intervention to the students to get information from them about their activities and opinions. The researcher asked the students to fill the questionnaire by reading the questionnaire and put a tick to one of the responses.

c. Using test

The pre intervention test named test 1(Appendix A) was administered by the researcher to the ninety-five (95) second year chemistry students of Breman Asikuma SHS, Breman Asikuma. The test results were used to determine each student's prior knowledge, competency and difficulties faced in titrimetric analysis work before the start of the intervention. The laid down rules and regulations of WAEC for conducting examinations were observed during the administration of the test and the entire answered test scripts were collected, marked, recorded and the scores collated for analysis.

3.8.2 Planning the Intervention Activities

Before implementing the action, the researcher needed to make general plan. Developed a plan of critically informed action to improve what was already happening. The researcher also prepared equipment needed in doing the action in order to enhance the students' titrimetric analysis skills.

The researcher prepared everything needed in the research as follows:

1. Preparing materials for the teaching, making lesson plan, and designing the steps in doing the actioned
2. Determining initial base scores
3. Assigning the students to team

4. Preparing students' worksheets
5. Preparing draft for the interview
6. Preparing sheets of classroom observation (to know the situation of teaching - learning process when teaching technique is applied)
7. Dividing teaching into three phases

3.8.3 Intervention Stage (Implementing the Action)

The researcher implemented the teaching and learning of titrimetric analyses by using Student Teams-Achievement Divisions (STAD) to help the students understand the material in five weeks.

The implementations generally were presented as follows:

a. Pre-titrimetric analyses activities

In each week of the instruction, the researcher facilitated the students to build up their background knowledge. In this phase, the researcher showed some related picture for focusing students' attention. Then, gave the brainstorming related to the activities.

b. Main titrimetric analyses activities

In this stage, the researcher gave tasks for the students. The tasks were exercises, practices, and various activities that were done by students.

c. Post-titrimetric analysis activities

The researcher asked students questions to reflect on their titrimetric analyses activities and to relate it to their own experiences. It allowed the researcher to see how well the students have understood what they had done. It was also done to measure the students' improvement after they were taught using Student Teams Achievement Divisions (STAD).

The five (5) weeks of instructions of 80 minutes per week were used as follow:

First Week

Rudiments and precautions to be taken during acid - base titration

To make the lesson activity oriented and ensure full participation, the researcher put the students into ten (13) groups of a maximum number of five (5) based on the philosophy of STAD. Students then were taught some of the rudiments and precautions to be taken during acid - base titration. The under listed were some of the rudiments and precautions taught using the STAD:

1. Unless otherwise stated, it is usual that:

    i. *The acid is put in the burette.*

Reason: The acid will not react with the glass or stop cock of the burette.

    ii. *The alkali is normally put into the conical flask but* **not** *the burette.*

Reason: The alkali will react with the glass or stop cock of the burette if put in it.

NB: If alkali is put in the burette, it must be washed thoroughly with plenty water immediately after use.

2. Rinse the burette with the acid solution to be used and fill it again with the same acid solution and adjust to a convenient level.

Reason: The rinsing is necessary in order not to decrease the concentration of the acid by the water left on the sides of the burette after washing with distilled water.

3. Rinse a $20cm^3$ or $25cm^3$ pipette with the solution of the base (or acid) to be pipette.

Reason: The rinsing is necessary in order not to decrease the concentration of the base (or acid) by the water left on the sides of the pipette after washing with water. Pipette out $20cm^3$ or $25cm^3$ portions of the base into **three** clean conical flasks.

4. The acid used for rinsing the burette should **not** be poured back into the given acidic solution

Reason: This is to avoid diluting the acid with drops of water that sticks to the sides of the burette when washed with water.

5. The base used for rinsing the pipette should **not** be poured back into the giving alkali solution.

Reason: This is to avoid diluting the base with drops of water that sticks to the sides of the pipette when washed with water.

6. Two or three drops of a suitable indicator are added to the pipetted solution, that is, small quantity of the indicator is used.

Reason: To obtain sharp and clear colour change at the end point.

7. The acid is run gradually and carefully from the burette to the base in the flask and **not** added from a measuring cylinder.

Reason: This is to ensure higher accuracy in the volume of acid used. Since the burette can be easily manipulated for drop-wise addition and for easier end point than a measuring cylinder.

8. A piece of white tile is usually placed under the conical flask during titration.

Reason: This is to detect the end-point or to see colour change clearly.

9. The burette readings should be correct to **two** decimal places.

Reason: This is the highest degree of accuracy the burette in school can record.

NB: Titre values that are **not** consistent should **not** be averaged

10. At least **two** sets of readings should be obtained for the titration experiment.

Reason: In order to get accurate titre values

11. The burette should be rinsed with solution to be put in it before use.
12. The pipette should be rinsed with solution be pipette before use.

13. One needs to ensure that the burette does **not** leak.

14. The funnel should be removed after filling the burette.

15. The conical flask should be washed / rinsed with distilled water only.

16. When filling the burette and pipette one needs to avoid trapping air bubble.

The apparatus, procedures and precautions to be taken are shown in figure 2, 3 and 4 respectively below.

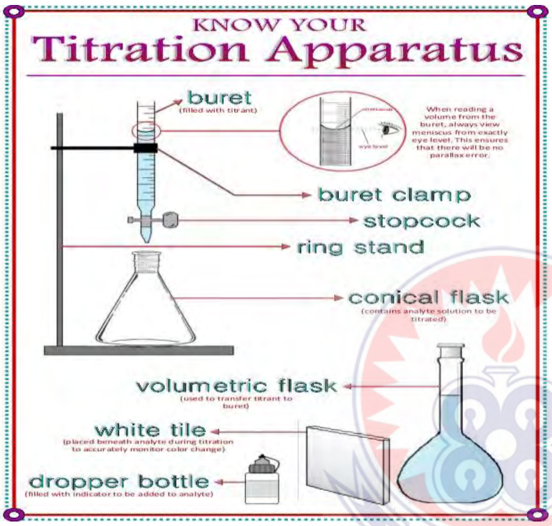

Figure 2: Titration Apparatus

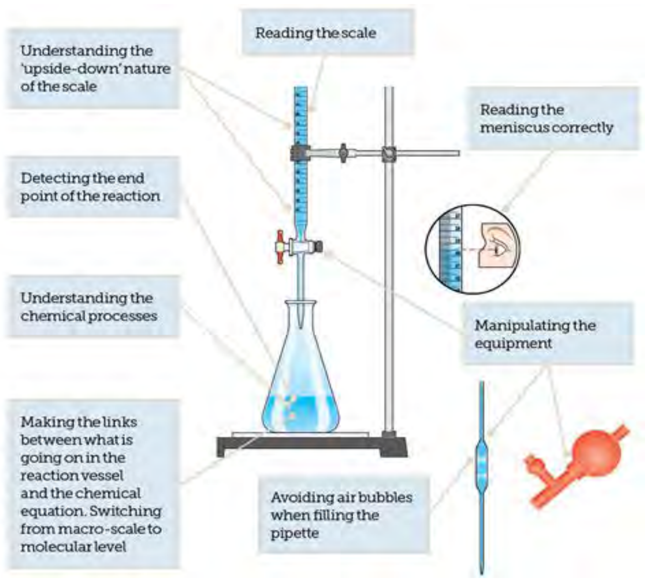

Figure 3: Some Manual Skills in Titration

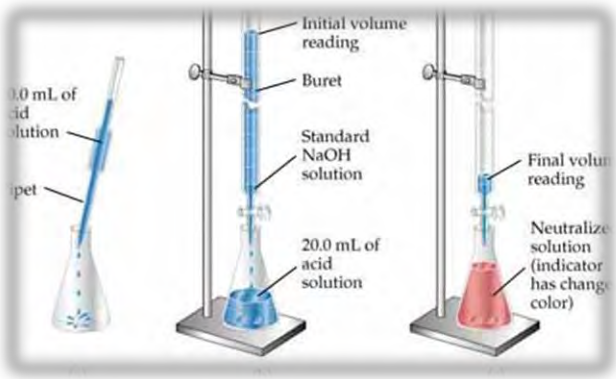

Figure 4; Set-up and procedure in titration process

Second Week

Choice of indicators in acid- base titration

The researcher used this week to help students identify the choice of indicators in acid-base titration with the STAD as shown in Table 1.

Table 1: Suitable indicators for acid-base titrations

Titration	Acid-base indicator	Nature of salt formed on the titration
1. Strong acid against strong base e.g. $HCl_{(aq)}$ and $NaOH_{(aq)}$	Methyl orange or phenolphthalein	Neutral **Reason:** Ions (Na^+ and Cl^-) from the salt (NaCl) formed in the titration do not hydrolyse. Eg. $NaOH + HCl \rightarrow NaCl + H_2O$ $NaCl_{(aq)} \rightarrow Na^+_{(aq)} + Cl^-_{(aq)}$
2. Strong acid against weak Base e.g. $HCl_{(aq)}$ and $NH_{3(aq)}$	Methyl orange	Acidic **Reason:** The cation (NH_4^+) from the salt (NH_4Cl) formed in the titration, undergoes hydrolysis to yield excess H_3O^+ making the solution acidic. Eg. $HCl + NH_3 \rightarrow NH_4Cl$ $NH_4Cl_{(aq)} \rightarrow NH_4^+{}_{(aq)} + Cl^-$ $NH_4^+{}_{(aq)} + H_2O \leftrightarrow NH_{3(aq)} + H_3O^+{}_{(aq)}$

Table 1 continued

3. Weak acid against strong base e.g. $CH_3COOH_{(aq)}$ and $NaOH_{(aq)}$	Phenolphthalein	Basic Reason: The anion (CH_3COO^-) from the salt (CH_3COONa) formed in the titration hydrolyses to yield excess OH^- making the solution basic. Eg. $CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$ $CH_3COONa_{(aq)} \rightarrow CH_3COO^-_{(aq)} + Na^+_{(aq)}$ $CH_3COO^-_{(aq)} + H_2O \leftrightarrow CH_3COOH_{(aq)} + OH^-$
4. Weak acid against weak base e.g. $CH_3COOH_{(aq)}$ and $NH_{3(aq)}$	No suitable indicator	

Third Week

Recording and Treatment of Titration Data

In this lesson, the researcher guided the students on how to record and treat titration data as shown in the Table 2.

Table 2: A hypothetical table for recording an acid – base titration data

Burette readings (cm^3)	Rough Titration	1st Titration	2nd Titration	3rd Titration
Final	Y_1	Y_2	Y_3	Y_4
Initial	X_1	X_2	X_3	X_4
Volume of acid used (titre)	$Y_1 - X_1$	$Y_2 - X_2$	$Y_3 - X_3$	$Y_4 - X_4$

If for example, the 1st and 2nd titrations are consistent, then

$$\text{Average volume of acid used} = \frac{(Y_2 - X_2) + (Y_3 - X_3)}{2}$$

Fourth week

Balancing chemical equations

The students were guided by the researcher on Balancing Chemical Equations using the STAD under the following steps:

Step 1:

Students were taught to write the unbalanced equation using the correct chemical formula for each reactant and product.

Step 2:

They were also guided to find suitable coefficients, which were the numbers placed before chemical formulas to indicate how many units of each substance were required to balance the equation.

Step 3:

They were to reduce coefficients to their smallest whole - number values, if necessary, by dividing them by a common factor.

Step 4:

Finally they were taught to check their answers to make sure that the numbers and kinds of atoms were the same on both sides of the equation.

Examples of some balanced chemical equations are shown below

(a). $NaOH + HCl \rightarrow NaCl + H_2O$

(b). $NaOH + HNO_3 \rightarrow NaNO_3 + H_2O$

(c). $H_2Y + 2KOH \rightarrow K_2Y + 2H_2O$

(d). $2HCl + Na_2CO_3.xH_2O \rightarrow 2NaCl + CO_2 + (x + 1)\,H_2O$

Fifth week

Approaches Used in the Computation of Solution Concentration

The researcher in his lesson explained to students the two major methods of standardizing solutions. Thus first principle method and mole ratio method. Students were taught these two methods with the STAD as follow:

The researcher made the students aware that the several methods were employed in standardization of solutions in volumetric analysis but only **two** would be considered. The standardization of solutions must usually be given to **three** significant figures.

Suppose a titration is carried out between solution A (H_2SO_4) in a burette and solution B (NaOH) in a conical flask and the following results were obtained:

Average titre (V_A) = 23.00cm^3

Concentration of H_2SO_4 (C_A) = 0.100 moldm^{-3} (3 significant figures)

Volume of NaOH used (V_B) = 25.00cm^3 Concentration of NaOH (C_B) =?

i. First Principle method

1000 cm^3 of H_2SO_4 contains 0.100 mole H_2SO_4

$\therefore$ 23 cm^3 of H_2SO_4 contains $\frac{23}{1000} \times 0.100 = 0.0023$ moles of H_2SO_4

Equation for the reaction is $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

From the equation,

1 mole of $H_2SO_4 \equiv$ 2 moles of NaOH

$\therefore$ 0.0023 mole of $H_2SO_4 = \frac{0.0023 \times 2}{1} = 0.0046$ mole of NaOH

Thus 25 cm^3 of NaOH contains 0.0046 mole of NaOH

$\therefore$ 1000cm^3 of NaOH would contain $\frac{1000 \times 0.0046}{25} = 0.184$ mol of NaOH

Thus concentration of NaOH = 0.184 moldm^{-3} (3 significant figures)

ii. Mole ratio method

Number of moles (n) = Concentration (mol dm^{-3}) × Volume (dm^3)

Number of moles of H_2SO_4 (n_A) = C_AV_A

Number of moles of NaOH (n_B) = C_BV_B

C_A = 0.1 mol dm^{-3}; V_A = 23.00 cm^3; V_B = 25 cm^3; C_B = ?

Equation for the reaction is: $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

From the equation, $n_A = 1$, $n_B = 2 \mapsto \frac{n_A}{n_B} = \frac{1}{2}$

$$\therefore \quad \frac{C_AV_A}{C_BV_B} = \frac{1}{2} \quad \Longrightarrow C_B = \frac{2 \times C_AV_A}{V_B} = \frac{2 \times 0.100 \times 23}{25} = 0.184 \text{ moldm}^{-3}$$

OR

$$\frac{C_{H_2SO_4} \times V_{H_2SO_4}}{C_{NaOH} \times V_{NaOH}} = \frac{1}{2} \Longrightarrow C_{NaOH} = \frac{2 \times C_{H_2SO_4} \times V_{H_2SO_4}}{V_{NaOH}} = \frac{2 \times 0.100 \times 23}{25} = 0.184 \text{ moldm}^{-3}$$

Observing or monitoring the action

The teacher, as the researcher, observed all activities in the teaching and learning process while the technique of teaching titrimetric analysis using Student Teams-Achievement Divisions (STAD) was carried out. The researcher also monitored and wrote the responses of the pupils in the class. The researcher also noted events happening in the teaching learning process. Again, the researcher created a conductive atmosphere to increase the students' motivation in titrimetric analysis, for example by giving suggestion, helping them in times of their difficulties while learning, and giving feedback for their efforts.

3.8.4 Post-intervention stage

At this stage, the post-intervention test named Test 2 (Appendix B) of comparable standards as the pre-intervention test (Test 1), was administered to the students under study. Procedures and conditions for the test 1 were repeated during the post-intervention test. This was done to compare students' performance and find out if there was any improvement after the use of the STAD to improve the performance of the students in the titrimetric analysis.

3.8.4.1 Reflecting and the result of the observation

Reflection is to find the problems in the activities so that the researcher can determine the next design better than before. The researcher made an evaluation based on his observation to identify the weaknesses during the action. This evaluation was to be a basic consideration to conduct the next cycle of teaching.

3.8.4.2 Revising the plan

Based on the weaknesses found from the activity that has been carried out, the researcher revised the plan for the next cycle. The classroom action research was to take one or more cycles until the goal of the research to be reached. It was done to get better results of the method the researcher applied.

3.9 Data analysis procedures

Data analysis is the process of simplifying data in order to make it comprehensive (Jack & Norman, 2003). Also, data analysis refers to the process of systematically searching and arranging the interview transcripts, field notes, and other materials that were accumulated to produce findings (Bogdan and Bilklen, 2007). It was also the process of converting raw data collected into usable information. At the end of data collection, data analysis was carried out to show how each variable contributed to performance in titrimetric analysis. The questionnaires were counter checked for adequate completion by the researcher.

The data was first coded in a computer and analyzed using the Statistical Package for Social Science (SPSS) version 20 both qualitatively and quantitatively. The data was organized into tables and descriptive statistics in the form of simple percentages, frequency counts, means and standard deviation were used to answer the research questions on the performance and difficulties of Chemistry students in titrimetric analysis. However, the samples of wrong answers of the selected students that were interviewed were presented and discussed to ascertain the difficulties the students encountered.

Analysis of students' responses to the various questions in the Test 1 and Test 2 was based on the following:

- Students' difficulties
- Precautions to be taken during acid – base titrations
- Balancing of chemical equations
- Recording and Treatment of Titration Data
- Approaches Used in the Computation of Solution Concentration in mol/dm^3 and g/dm^3.

Statistical Package for Social Science (SPSS) version 20 was also used to analyse students' responses to the questionnaire on a five point Likert type scale which helped to determine the mean value percentages.

The results of pre-intervention test and post-intervention test were analyzed to compare the percentages and the mean scores in order to know the difference before and after the use of the STAD The means scores of the male and the female were also compared to know the differences in the performance of male and female students in titrimetric analysis using the STAD after the intervention.

The mean of the pre- intervention test and post-intervention test were calculated with the formulas as follows:

$$\bar{y} = \frac{\sum y}{N} \qquad \bar{X} = \frac{\sum X}{N}$$

Where:

$\bar{x}$: means of pre- intervention test score

$\bar{\bar{y}}$: means of post-intervention test score

N: the number of sample

$\sum\bar{x}$ = the sum of pre- intervention test score

$\sum\bar{y}$ = the sum of post-intervention test score

Discussions of the findings were made based on the research questions. On the basis of analysis the findings, conclusions and recommendations were made.

3.10 Ethical considerations

In this study, the researcher, interacted deeply with the participants at a personal level, thus entering their personal domains of weaknesses and challenges, while collecting the data. Creswell (2012) argued that qualitative researchers were obliged to respect the rights, needs, values, and desires of the participants. Thus, Creswell (2012) suggested that appropriate steps should be taken to observe strict ethical guidelines in order to maintain participants' privacy, dignity, rights, confidentiality and anonymity.

To adhere to research ethical guidelines, the researcher informed the participants of the purpose, nature, data collection and duration of the study. The headmaster of the school and teachers teaching the participants were also informed and their consent sought. In the consent letters, the researcher guaranteed that no participant would be exposed to any harm, either physically or psychologically, during the study. The researcher assured the headmaster that the confidentiality and anonymity of the participants would be maintained during the study and in the dissemination of the results. It was also made clear that the participation was absolutely voluntary and that participants were free to withdraw from the study whenever they felt like doing so without any fear of being penalized in any way.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

In this chapter, the results of the study are presented and discussed in relation to the four research questions. The discussions of the research questions were based on the analysis of data obtained from achievement tests (pre-intervention test, intervention and post-intervention test), informal interview and questionnaire. A number of tables were constructed for easy presentation and analysis of data. The research questions that guided the results and the discussions are:

1. What difficulties do the students encounter during theory and practical lessons on titrimetric analyses?
2. What is the effect of the STAD on the students' performance on titrimetric analyses?
3. What are the views of the students on the use of the STAD to teach titrimetric analyses?
4. What are the differences in the performance of male and female students on titrimetric analyses using the STAD as the intervention?

4.1 Results by Research Questions

Research Question One: What difficulties do the students encounter during theory and practical lessons on titrimetric analyses?

This research question was meant to find out difficulties students encountered during theory and practical lesson on titrimetric analysis before the intervention. To show this, the researcher categorized the items into:

A. Some scientific terminologies associated with titrimetric analyses

B. Indicators

C. Manual skills acquisition in titration (Titrimetric Analyses)

Students' performance however was presented for each of the test items in each categories (A, B and C Appendix A). The results of their wrong answers brought out clearly the difficulties that students faced. It was observed that there were differences in the difficulty level of the items scores.

4.1.1 Students' difficulties with some scientific terminologies associated with titrimetric analyses

The two questions in Table 10 (Questions 1 and 2) below attempted to examine the students understanding of certain scientific terms used to describe aspects of the acid-base titration. The two terminologies examined were indicator endpoint and stoichiometric point. In the first response pattern in Question 1, 5 students correctly related the endpoint to the colour changes occurring in the indicator (33.3%). In the second response pattern an appreciable number of 6 students (13.3%) assumed that the endpoint always occurs at pH of 7 when the solution is neutral. That is, they saw the endpoint as the neutralization point. In the third response pattern, 3 students (20.0%) defined the endpoint just like the stoichiometric point. Although the endpoint may not necessarily coincide with the stoichiometric point, when the students were questioned further on the relationship between the two terms, they maintained that they were the same. Thus, no attempt was made by the students to distinguish between the stoichiometric points of the reaction from the indicator endpoint. The responses further depict that a significant number of students (4) representing 26.7% did not know what endpoint meant.

Similar response patterns were noted for the stoichiometric point (Question 2 in Table 10). However, here, quite a large number of the respondents (40.0%) seemed to show an understanding of what stoichiometric point or equivalence point meant. No attempt was made by the, researcher to see if the student, understood both of these terms. The students were required to explain any one of the terms that they knew. As the third response pattern showed, only a few students related the stoichiometric point to neutralization. In the second response pattern, stoichiometric point was described in terms of the concentrations of acid and base instead of the moles of acid and base. These students did not seem to differentiate between moles and concentrations. The fifth response pattern indicated that quite a large number of the respondents (26.7%) did not know what stoichiometric or equivalence point meant although most of these students used one of these terms in their responses. The students' responses to items on some terminologies on titrimetric analyses were presented in Table 3.

Table 3: Students' responses to items on some terminologies on titrimetric analyses

Response Pattern	No. of students (N=15)	Percentage (%)
Question 1: What is the endpoint in a titration?		
1. When the colour of the indicator changes	5	33.3
2. When the solution is neutral	2	13.3
3. When there are equal amounts of OH- and H+ ions	3	20.0
4. When concentration of both acid and base are equal	1	6.7
5. I don't know	4	26.7
Question 2: What is the stoichiometric point or equivalence point in titration?		
1. When the moles of OH- and $\boldsymbol{H^+}$ ions are equal	6	40.0
2. When the concentration of $\boldsymbol{H^+}$ and $\boldsymbol{OH^-}$ ions are equal	2	13.3
3. When the solution is neutral	2	13.3
4. The volume of the acid is equal to volume of base	1	6.7
5. I don't know	4	26.7

4.1.2 Students' difficulties with indicator behaviour

In Question 3, in Table 4, all the students, in one way or the other, seemed to know the function of the indicator in the titration of HCl against NaOH. Those who gave response pattern 4, indicated that if in the titration, a base is being added from the burette to the acid then an indicator should be chosen which changes in the basic pH range. These students, therefore, did not seem to have a correct conception of the function of an indicator. With regard to those who indicated that the final solution would be neutral. Examination of their responses to follow-up questions relating to the pH at the stoichiometric point for the reactions between HCl and NaOH, NH_3, and HCl, and acetic acid and NaOH seemed to indicate generally that they regarded every acid-base reaction to result in a neutral solution irrespective of the nature of the reactants. Despite this confusion, it could be inferred that the respondents generally understood why indicators were used in acid-base titrations involving strong acids and strong bases.

However, as the responses on (Question 4 in Table 4) showed, quite a large percentage (46.7%) of the respondent (7) either did not know how the indicator used in the titration changed colour or they conjured up some other explanations. In the first response pattern, 4 students representing (26.6%) realized that the colour of the indicator was determined by the proportion of the undissociated form and the dissociated form (or conjugate acid or base). In the second response pattern, 13.3% of the students seemed to have the notion that the hydrogen ions in the solution combined with the indicator to form coloured compounds. In the third response pattern reference was made to the transfer of electrons or the effect of light on electrons in solution as the cause of the colour changes.

When asked about the effect of using a large volume of the indicator (Question 5 in Table 4), only about a quarter of the respondent indicated that the indicator would affect the titration results. These students seemed to realize that since the indicator was a weak acid or base it would react to increase (if it's a weak acid) or decrease (if it's a weak base) the volume of the base.

The large number of students who indicated that the increased volume of the indicator would not affect the titration results, reasoned in two main ways. One group (13.3%) reasoned that the indicator only made the colour deeper and hence more perceptible. A second group (26.6%) reasoned that the indicator was only used to indicate when the reaction was complete and as such should not affect the volume of added base. These students also seemed to address themselves basically to the function of the indicator. Some of these students indicated by their responses that the indicator was a neutral substance or, even if it was an acid, it was so weak that it did not have sufficient hydrogen ions to make a difference. Students' responses on items on indicator behaviour are shown in Table 4.

Table 4: Students' responses on items on indicator behaviour

Response Pattern	No. of students (N=15)	Percentage (%)
Question 3: Why is an indicator needed in this titration?		
1. To indicate when the moles of base equals moles of acid	7	46.7
2. To indicate when the solution is neutral	4	26.6
3. To indicate when the solution has reached a certain pH range	2	13.3
4. To show when the solution is basic	1	6.7
5. I don't know	1	6.7

Table 4 continued

Response Pattern	No. of students (N=15)	Percentage (%)
Question 4: You noted that the indicator had different colours in different mediums, how does the indicator change colour?		
1. The indicator is a weak acid or base with two differently coloured forms in equilibrium. The proportion of these forms in solution determines the colour of the solution	4	26.6
2. The indicator reacts with the H^- or OH^- ions to form coloured compounds	2	13.3
3. It's something to do with electrons in solution	1	6.7
4. I can't explain	7	46.7
5. Other	1	6.7
Question 5: Do you think the amount of indicator added will affect the final volume of base used in the titration? Why?		
1. Yes, the indicator will react with the base to affect the volume of the base	5	33.3
2. It will affect the volume of base because the indicator will increase the pH of the acid.	1	6.7
3. It will affect it but I don't know why	1	6.7
4. I don't think so because it only-makes the colour more perceptible	2	13.3
5. No because an indicator is only there to show the endpoint	4	26.6
6. I don't think so because the indicator is a weak acid	1	6.7
7. I don't know	1	6.7
Question 6: Why did you choose this (particular) indicator for the titration?		
Phenolphthalein		
1. Because pH range falls on vertical section of the graph	1	6.7
2. Because it changes in the basic range	1	6.7
3. Because it gives a distinct colour	2	13.3
4. Because the acid is in the titrating flask	1	6.7
5. Because I'm familiar with it	3	20.0
6. I don't know	1	6.7
7. Because the reaction is completed between pH 8 and 10	1	6.7
8. Because phenolphthalein is in the neutral pH range	1	6.7

Table 4 continued

Response Pattern	No. of students (N=15)	Percentage (%)
Methyl orange		
1. Because the acid is in the flask	1	6.7
2. Because it gives a distinct colour	1	6.7
3. I don't know	1	6.7
All two indicators		
1. To make sure that at least one of them indicates the endpoint	1	6.7
Question 7: If acetic acid is used in the titration instead of HC*l* which of the 2 indicators (phenolphthalein and methyl orange) will you use in the titration? Why?		
Phenolphthalein		
1. Because it changes in the basic range	1	6.7
2. Because it's pH range coincides with the stoichiometric point	3	20
3. Because pH at equivalence point is 7	1	6.7
4. Because it is a weaker acid than acetic acid	1	6.7
5. Because it is used when acid is in the flask	1	6.7
6. Because I'm familiar with it	2	13.3
7. I don't know	1	6.7
Methyl Orange		
1. Because acetic acid is a weak acid	1	6.7
2. Because it is used when the acid is in the flask	1	6.7
3. I don't know	1	6.7
None		
1. I don't know	2	13.3
Question 8: If ammonia is used in the titration which indicator out of the three will you choose?		
1. Phenolphthalein	7	46.7
2. Methyl orange	5	33.3
3. I don't know	3	20

4.1.3 Students' difficulties in manual skills acquisition in titration (titrimetric analysis)

To identify the specific difficulties that students have when performing laboratory titrations, an analysis was done on the data from the interview conducted and used to identify these difficulties after students were asked to do at least three titration each.

Table 5 shows the total number and the percentage of the respondent in each specific laboratory skill.

From Table 5, about 46.7% of the respondents demonstrated superior skills in the handling of a burette while 33.3% of the respondents displayed inadequate skills in the handling of a burette. These adequate responses were also given for questions 2, 3 and 4 from Table 5. The large percentage of respondents to the above questions showing at least an adequate skill in the use of the burette and indicator might be ascribed to the fact that invariably in any titration conducted in the school, a burette and indicators were used. Table 5 below shows responses on students' difficulties in manual skills acquisition in titration (Titrimetric Analyses).

Table 5: Data on interview on students' difficulties in manual skills acquisition in titration (Titrimetric Analysis)

SN	Type of Skills	No. of students (N=15)	Responses	
A.	**Skills in Using Lab Equipment**	**Inadequate**	**Adequate**	**Superior**
1	Skills displayed in the handling and reading of burette	5 (33.3)*	3 (20.0)	7 (46.7)
2	Skills displayed in the handling and reading of pipette	2 (33.3)	5 (13.3)	8 (53.4)
B.	**Skills in Performing Lab Techniques**	**Yes**		**No**
3	Does the student need help in setting up the experiment?	3 (20.0)		12 (80.0)
4.	Is an indicator added to the solution before titration?	14 (93.3)		1 (6.7)
5	Is caution exercised near the endpoint?	5 (33.3)		10 (66.7)
6	Does the student overshoot the endpoint?	8 (53.3)		7 (46.7)
7	Is the flask constantly shaken during the titration?	11 (73.3)		4 (26.7)

Table 5 continued

8	Is a white background used to detect colour changes?	5 (33.3)	10 (66.7)	
9	Is the inside of the flask or beaker rinsed with distilled water during the titration?	3 (20.0)	12 (80.0)	
10	Is the first titration regarded as final?	9 (60.0)	6 (40.0)	
11	Are data recorded immediately after readings are made?	8 (55.3)	7 (46.7)	
		2	**1**	**0**
12	To how many decimal places is the burette read?	1 (6.7)	10 (66.7)	4 (26.6)
		Pipette	**Burette**	**Measuring cylinder**
13	To obtain volume of acid student uses	5 (33.4)	2 (13.3)	8 (53.3)
		Yes	**No**	
14	Is container used for titration	9 (60.0)	6 (40.0)	
15	Is funnel used for transferring solutions into burette	8 (53.3)	7 (46.7)	
16	Is the conical swirled during the titration?	3 (20.0)	12 (80.0)	
17	Is the funnel removed from the burette before the reading of the volume?	2 (13.3)	13 (86.7)	
18	Is the reading in the burette done at the bottom of the meniscus?	5 (33.3)	10 (66.7)	
19	Is the conical held with the right hand and the tap/clip of the burette held by left hand?	2 (13.3)	13 (86.7)	
20	Is the air space removed before the reading on the burette?	4 (26.7)	11 (73.3)	

*** Parentages in parenthesis**

Research Question Two: What is the effect of the STAD on the students' performance on titrimetric analyses?

Research question two was meant to determine the effect of the STAD on the students' performance on titrimetric analyses.

Table 6 contained data on students' responses to items in section A, B, C, D and E of the questionnaire before the intervention (Appendix A). The analysis of the total marks of the responses to the sections A, B, C, D and E of the questionnaire during the pre-intervention showed that 26 students out of the total sample of the study, representing 27.3% scored mark within the range 0-19, majority of the sample (42 students) representing 44.2% scored mark between 20-39. Eighteen of the students representing 19.0% scored within 40-59, 9 of the respondents representing 9.5% scored within the range of 60-79 while none of the respondents scored a mark above average in the ranges 80-99. These results are shown in Table 6.

Table 6: Pre- intervention test results

Marks	No. of students	Percentage of students (%)
0-19	26	27.3
20-39	42	44.2
40-59	18	19.0
60-79	9	9.5
80-99	0	0
Total	**95**	**100**

Table 7 contained the scores, number and percentage of students who responded to the post-intervention test items. The results of the analysis of the total marks of the students in test items in section A, B, C, D and E of the questionnaire showed that 5 students representing 5.3% of the sample scored between 0 and 19, out of total marks. Eight students 8.4% of the sample scored between 20 and 39 marks. Fifteen students representing 15.8% of the sample also scored between 40 and 59 out of the total marks of 100. Majority of the sample (51 students) representing 53.7% of the respondents scored marks ranging from 60-79. The remaining 16.8% of the students (16 students) had above average in the ranges 80-99. The results of this part of the questionnaire (section A, B, C, D and E) after the intervention are shown in Table 7.

Table 7: Post- intervention test results

Marks	No. of students	Percentage of students (%)
0-19	5	5.3
20-39	8	8.4
40-59	15	15.8
60-79	51	53.7
80-99	16	16.8
Total	**95**	**100**

From Table 8, majority of the students (86 out of 95) performed below 50% on the pre-intervention test. Only 9 students performed well. From Table 8, only about 28 out of 95 students performed poorly in the post-intervention test, an improvement of 58 students over the pre-intervention test. A total of 67 students performed creditably well, out of 95 students.

Moreover, the data from Table 8 showed that the mean score for the pre-intervention test was 31.6 and the mean score for the post- intervention test was 61.1. The mean difference of the two test scores was 29.5. It was clear that the mean score for the post-intervention test was greater than the mean score for the pre-intervention test as shown in Table 8.

Table 8: Pre- intervention and post-intervention test results

Class Boundary	Class Mark (x)	Pre- Intervention		Post- Intervention	
		Frequency (f)	fx	Frequency (f)	fx
0-19	9.5	26	247	5	47.5
20-39	29.5	42	1239	8	236
40-59	49.5	18	891	15	742.5
60-79	69.5	9	625.5	51	3544.5
80-99	89.5	0	0	16	1432
Total		**95**	**3002.5**	**95**	**6002.5**
			M= 31.6		M = 61.1

Research Question Three: What are the views of the students on the use of the STAD to teach titrimetric analyses?

This question sought to determine the views the students held about the use of the STAD to improve the performance of students in titrimetric analyses. The views of the respondents in the questionnaire were analysed using simple percentages on item-by-item bases as presented in Table 9.

Table 9: Student's views about the use of the STAD to teach titrimetric analyses.

SN	Item	SA	A	U	D	SD	Total
1	The STAD motivated students in teaching and learning of the terminologies in titrimetric analysis.	83 (87.4)*	12 (12.6)			86	95 (100%)
2	The STAD made lesson noisy	1 (1.1)	1 (1.1)	65 (68.4)	7 (7.3)	21 (22.1)	95 (100%)
3	The STAD made the lesson more interesting	88 (92.6)	6 (6.3)	1 (1.1)			95 (100%)
4	The STAD confused me to identify the commonest acid-base indicators often used in titration process		1 (1.1)	1 (1.1)	8 (8.3)	85 (89.5)	95 (100%)
5	The STAD made me learn easily from colleague classmates.	90 (94.7)	4 (4.2)	1 (1.1)	0	0	95 (100%)
6	The STAD as a teaching and learning strategy helped me participate actively in class for skills acquisition on titration / titrimetric / quantitative process.	78 (82.0)	14 (14.7)	1 (1.1)	1 (1.1)	1 (1.1)	33
7	It was difficult to work with colleague classmates in balancing chemical equations with the use of the STAD as a teaching and learning strategy		1 (1.1)	1 (1.1)	4 (4.2)	89 (93.6)	95 (100%)
8	The STAD as teaching and learning strategy for titrimetric analysis was boring.	1 (1.1)		1 (1.1)	7 (7.3)	86 (90.5)	95 (100%)
9	The STAD made lesson abstract.			1 (1.1)	4 (4.2)	90 (94.7)	95 (100%)
10	The STAD helped me to identify the basic acid-base indicators often used in titration process with little help.	86 (90.5)	8 (8.4)	1 (1.1)			95 (100%)
11	The STAD made solving of problems application of titration standardization of solutions in volumetric analysis self - explanatory.	82 (86.2)	10 (10.5)	1 (1.1)	1 (1.1)	1 (1.1)	95 (100%)
12	The STAD made me inactive in titrimetric process in the lesson.		2 (2.1)	1 (1.1)	6 (6.3)	86 (90.5)	95 (100%)
13	At anytime and anywhere the STAD can be used	78 (82.0)	15 (15.8)		1 (1.1)	1 (1.1)	95 (100%)
14	The STAD as teaching strategy for titrimetric process was time consuming.	18 (18.9)	2 (2.1)	60 (63.2)	5 (5.3)	10 (10.5)	95 (100%)

*** Parentages in parenthesis**

It could be seen from Table 9 that majority of the students (83) representing 87.4% strongly agreed that the use of the STAD in teaching the titrimetric analysis motivated them and 88 students representing 92.6% strongly agreed that STAD made the lesson more interesting. Again, 90 students representing 94.7% strongly agreed that STAD made students learn easily from colleague classmates. The STAD as a teaching and learning technique made students participate actively in class for skills acquisition in titration / titrimetric / quantitative process as was strongly agreed by 78 students representing 82.0%. Eighty- six students representing 90.5% strongly agreed that the STAD helped students to identify the basic acid-base indicators often used in titration process with little help. Eighty- two students representing 86.2% strongly agreed that the STAD made solving of problems on application of titration standardization of solutions in volumetric analysis self -explanatory. Seventy-eight students representing 82.0% strongly agreed that the STAD could be used anywhere and anytime.

However, 85 students out of the total sample representing 89.5% strongly disagreed that the STAD confused them to identify the commonest acid-base indicators often used in titration process. Also 89 students representing 93.6% strongly disagreed that it was difficult for students to work with colleague classmates in balancing chemical equations with the use of the STAD as a teaching and learning strategy. Eighty-six students representing 90.5% strongly disagreed that the STAD made the lesson boring. Ninety students representing 94.7% strongly disagreed that the STAD made lesson abstract. Finally, 86 students representing 90.5% strongly disagreed that STAD made student inactive.

On the other hand, however, 65 students representing 68.4% were uncertain that the STAD made lesson noisy and 60 students representing 63.2% were uncertain that STAD as teaching and learning strategy was time consuming. Students were also given open ended items to show their views on the use of the STAD as technique in teaching titrimetric analyses. This was meant to allow for free expression about their views. They were made to respond to the items as “YES”, “UNCERTAIN” and “NO” with reasons. Their reasons were grouped under five (5) main themes. The researcher deemed the grouping necessary because the researcher realized that similar ideas had been expressed in different language forms by individual respondent.

Table 10 showed the summary of open-ended response from the students. From Table 10, 88 students (92.3%) appreciated the use of the STAD in teaching titrimetric analysis. Again, 7 students (7.7%) from Table 10 were indecisive with a reason that they were not regular during the intervention stage (Appendix G sample 4). Table 10 below shows the summary of open-ended responses from the students.

Table 10: Summary of open-ended responses from the students.

Responses	Frequency (n)	Percentages (%)
Yes	88	92.3
No	-	-
Uncertain	7	7.7
Total	**95**	**100**

However, there was no objection to the use of the STAD. There was therefore a positive indication from the respondents on the use of the STAD as a very good teaching and learning technique.

Table 11 shows the summary of students' reasons for their choice to the open ended questions.

Table 11: Summary of students' reasons for their choice to the open ended questions

Reason	Frequency (n)	Percentage (%)
Interesting and motivating	25	26.3
Active participating	40	42.1
Easy to work in group	15	15.8
Not confusing	5	5.3
Needs little help	10	10.5
Total	**95**	**100.0**

Table 11 above, shows that this group of respondents believed that the use of STAD made the lessons interesting and motivating (n=25, 26.3%), active participant (n=40, 42.1%), easy to work in group (n=15, 15.8%), not confusing (n=5, 5.3%) and finally made them to have little help (Appendix H, samples 1, 2, 3 and 4 respectively)

Research Question Four: What are the differences in the performance of male and female students on titrimetric analyses using the STAD as the intervention?

The last research question tried to find out which of the gender performs better than the other on the titrimetric analyses using the STAD. Regarding this question, the researcher provided data characteristics of the respondent in Table 12 for analysis. Table 13 depicts the data analysis of pre- intervention and post intervention scores of the female students. Table 14 shows the analysis of the pre- intervention and post-intervention scores of the male students for the same test results done together and Table 15 shows the mean analysis to ascertain which gender performs better in titrimetric analyses using the STAD.

It was observed from Table 12 that 55 representing 57.9% of the student respondents were males, and 40 forming 42.1% of them were females. This means there were more males than females studying chemistry in form two at the Breman Asikuma senior high school. Concerning the age of the students, it was noted that two representing 2.1% of the students were within ages 13 – 15 years, 72 constituting 75.8% of them were within ages 16 – 18 years, and 21 forming 22.1% of the students were within ages 19 – 21 years. This indicated that, most of the students used for the study were within the ages of 16 – 18 years which is very normal with second year senior high students in Ghana. Table 12 shows the background data of the students respondents.

Table 12: Characteristics of the respondents

Variable	Subscale	No.	Percentage (%)
Sex	Male	55	57.9
	Female	40	42.1
Age Range(Year)	13-15	2	2.1
	16-18	72	75.8
	19-21	21	22.1

Table 13 contains data on female students' responses to items in section A, B, C, D and E (Appendix A) of the questionnaire before the intervention. The analysis of the total marks of the responses to the sections A, B, C, D and E of the questionnaire during the pre-intervention showed that 16 students out of the total sample of the females (40) of the study, representing 40% scored mark within the range 0-19, as against 2 female students representing 5% for post- intervention results, a clear reduction of 35%. Again, 16 female students constituting 40% scored mark within 20-39 for pre-intervention as against 2 female students representing 5% for post-intervention results, a clear reduction of 35%. 5 female students representing 12.5% scored mark within 40-59, for pre-intervention as against 2 female students representing 5% for post-intervention results, a clear reduction of 7.5%. 3 of the female respondents representing 7.5% scored within the range of 60-79 for pre-intervention as against 22 female students representing 55% for post-intervention results, an improvement of 47.5%. While none of the female respondents scored a mark in the ranges 80-99 for pre-intervention, 12 female students representing 30% had scores for the post-intervention results an improvement over the pre-intervention results. These results are shown in Table 13.

Table 13: Pre-intervention and post- intervention test results for the female students.

Marks	Pre- Intervention		Post- Intervention	
	No. of students	Percentage of students (%)	No, of students	Percentage of students (%)
0-19	16	40	2	5
20-39	16	40	2	5
40-59	5	12.5	2	5
60-79	3	7.5	22	55
80-99	0	0	12	30
Total	**40**	**100**	**40**	**100**

Table 14 shows data on male students' responses to items in section A, B, C, D and E of the questionnaire before the intervention. The analysis of the total marks of the responses to the sections A, B, C, D and E of the questionnaire during the pre-intervention showed that 10 students out of the total sample of the males (55) of the study, representing 18.2% scored mark within the range 0-19, as against 3 male students representing 5.5% for post- intervention results, a reduction of 12.7%. 26 male students representing 47.3% scored mark ranged 20-39, for pre-intervention as against 6 male students representing 10.9% for post-intervention results, a clear reduction of 36.4%. 13 male students representing 23.6% scored mark within 40-59, for pre-intervention as against 13 male students representing 23.6% for post-intervention results. 6 of the male respondents representing 10.9% scored within the range of 60-79 for pre-intervention as against 29 male students representing 52.7% for post-intervention results, an improvement of 41.8%. While none of the male respondents scored a mark in the ranges 80-99 for pre-intervention results, 4 male students representing 7.3% for post-intervention results, an improvement over the pre-intervention results. These results are shown in Table 14.

Table 14 : Pre-intervention and post- intervention test results for the male students.

Marks	Pre- Intervention		Post- Intervention	
	No. of students	Percentage of students (%)	No, of students	Percentage of students (%)
0-19	10	18.2	3	5.5
20-39	26	47.3	6	10.9
40-59	13	23.6	13	23.6
60-79	6	10.9	29	52.7
80-99	0	0	4	7.3
Total	**55**	**100**	**55**	**100**

From Table 15, majority of the female students (37 out of 40) and male students (49 out of 55) performed below 50% on the pre-intervention test. Only 3 female students and 6 male students performed well. From Table 15, only about 6 female students out of 40 and 22 male students out of 55 performed poorly in the post-intervention test, an improvement of 34 and 33 students respectively over the pre-intervention test. A total of 32 female students and 33 male students performed creditably well, out of 40 and 55 students respectively.

Above all, the data from Table 15 showed that the mean scores for the pre-intervention test for female students and male students were 27.0 and 35.0 and the mean scores for the post- intervention test for female students and male students were 69.5 and 60.2 respectively. Table 15 below shows the differences between the pre- intervention and post-intervention test results for female and male students.

Table 15: Differences between the pre- intervention and post-intervention test results for female and male students

Class Boundary	Class Mark (x)	Pre-Intervention For female		Post- Intervention Female		Pre- Intervention For male		Post-Intervention For male	
		Freq(f)	fx	Freq(f)	fx	Freq(f)	fx	Freq(f)	fx
0-19	9.5	16	152	2	19	10	95	3	28.5
20-39	29.5	16	472	2	59	26	767	6	177
40-59	49.5	5	247.5	2	99	13	643.5	13	643.5
60-79	69.5	3	208.5	22	1529	6	417	29	2015.5
80-99	89.5	0	0	12	1074	0	0	4	447.5
Total		**40**	**1080**	**40**	**2780**	**55**	**1922.5**	**55**	**3312**
			M=27.0		**M =69.5**		**M= 35.0**		**M=60.2**

4.2 Discussion of Results

The discussions of the results seek to interpret and provide meaning to the results in an attempt to answer the research questions which guided this study. In the discussion below, answers were found for the research questions posed in chapter one.

4.2.1 Difficulties students encounter during theory and practical lessons on titrimetric analyses

The difficulties encountered during theory and practical lessons on titrimetric analyses that affected their performance in the pre-intervention scores were discussed under category A, B and C.

4.2.1.1 Students' difficulties with some scientific terminologies associated with titrimetric analyses

In general, it could be stated that even though the students used the correct terms (endpoint and stoichiometric point) in their descriptions, they seemed to have an inadequate understanding of these terms. This supported the observation that increased language sophistication by a subject is not necessarily followed by a greater depth of understanding of the terms used (Dahlgren & Marton, 1998). The inadequate understanding of the terms could be due to the fact that, in teaching titrimetric analyses, teachers were normally satisfied when they found out that the students could use the correct terms in their descriptions. They therefore, failed to go a step further to check on what the terms meant to the students. The possibility also exists that these terms might have been used unconsciously by the teacher; the students picked them up and started using them as part of their own language. Also, taken for granted is the fact that chemical knowledge was generated mainly in the classroom through the teachers' interpretation since there was very little chemical experience which the students have prior to formal instruction. It was possible that if cognizance was taken of these limitations, much could be done to help the students in their struggle to understand nature in chemical terms.

4.2.1.2 Students' difficulties with indicator behaviour

It could be stated in general that although quite a number of students realized that an indicator was a weak acid, from the responses in Table 4, they did not realize that if used in large amounts it would affect the volume of base needed in the titration. The inadequate conceptions that the students have of the behaviour of acid-base indicators in titration could also be noticed in their selection of indicators for the titration of HCl against NaOH and the reasoning behind their choice (Question 6 in Table 4). It was notable that a total of 73.5% of the interview respondents selected phenolphthalein while 20.1% chose methyl orange for the titration. It was interesting to note also that, most of the students explained their choices in terms of their experiences (familiarity) with the indicators. Of the respondents who chose phenolphthalein, 60% indicated in some way that their selection was based on their laboratory experiences. That is, either they were familiar with it, they knew it was used when acid is put in the conical flask or because it gives a distinct colouration. These students did not relate their choice to any chemical criteria. Only a few (6.7%) indicated that even though its pH range was beyond pH =7, they could still use it because of the wide range of pH change near the stoichiometric point of the reaction.

Thus, in all about 86.6% of the total students sampled, used particular indicators for the titration of HCl with NaOH because of their experiences. The above trend in the choice of indicators noted for the titration of HCl with NaOH could also be found to some extent in the choices made by the students in the titration of acetic acid against sodium hydroxide (Question 7 in Table 4) and the titration of ammonia against sodium hydroxide (Question 8 in Table 4). With the NaOH - acetic acid reaction, there seemed to be a slight shift both in the proportion selecting a particular indicator and the reasons offered by the students to explain their choice. Instead of relating it to their laboratory experiences, half of the students who made the correct choice (i.e. chose phenolphthalein) explained their selection by relating the pH range of the indicator to the pH at the stoichiometric point for the reaction between acetic acid and sodium hydroxide. These students alluded to the strength of the acid and base and the ensuing hydrolysis to explain the pH of the final solution. However, still an appreciable proportion of those who chose phenolphthalein (66.8%) indicated that their choice was based on their laboratory experiences. In fact, those who said they were familiar with phenolphthalein indicated that they had not used the other indicators to any appreciable extent so they just stuck to what they have been using in the laboratory. Also those who indicated that phenolphthalein was used when the acid used in the titration was placed in the flask instead of the burette, seemed to think that if the acid was in the flask, then it suggested that one wanted a basic solution whereas the opposite would mean one wanted an acidic solution as the final solution. That is, the purpose of titration was to obtain an acidic or basic solution. These students therefore applied irrelevant variables like the position of the acid in the titration to explain their choice instead of looking at variables like the strength of the reactants, the hydrolysis resulting from their reaction and the probable acidity of the product of hydrolysis.

Those who made an incorrect choice mostly reasoned that the pH at the stoichiometric point would be 7 even though some of them knew that acetic acid was a weak acid. The same trend was noted in the titration of ammonia against hydrochloric acid (Question 8 in Table 4).

Those who chose methyl orange reasoned that since acetic acid was a weak acid and sodium hydroxide was a strong base, the equilibrium of the hydrolysis would shift toward the acid side of the pH scale. This showed an inadequate grasp of the concept of hydrolysis.

In general, it seemed that an adequate understanding of indicator behaviour, as it was reflected in Questions 4, 5, 6, 7, and 8 (Table 4) would require an understanding of:

a) the nature of indicators (i.e. what kind of substances they are),

b) the relationship between the pH at stoichiometric point for the reaction and the pH range of the indicator,

c) and the changes in pH during titration (i.e. a clear understanding of titration curves). The knowledge of the pH at the stoichiometric point of the reaction would in turn require knowledge of:

i) the nature of the acid and base involved in the titration - i.e. whether they are strong or weak, and

ii) whether their salt undergoes hydrolysis.

Even though all these concepts had been taught in class, the students often did not seem to apply them in their explanations. It was possible that in teaching titrimetric analyses, no attempt was made to use the right teaching technique to integrate these concepts into a coherent whole so as to present a total picture to the students. If the STAD integration were to be emphasized especially during lab activities, it might have gone a long way to improve the students' understanding.

4.2.1.3 Students' difficulties in manual skills acquisition in titration (titrimetric analysis)

However, analysis of the data in Table 5 showed that majority of the students as indicated by the percentages of the students from the interview question 5-20 displayed difficulties in manual skills acquisition in titration in the following important areas:

- Not rinsing the burette with distilled water for the base to be used in it.
- Not reading the bottom of the meniscus
- Not removing any trapped bubbles of air from the burette
- Not using of the pipette (hence using conical flask and measuring cylinder to measure the volume of the base)
- Doing less than three titration
- The student overshooting the end-point
- Conical flask constantly shaking and not swirling it during the titration
- Caution not exercised near the endpoint
- White background not used to detect colour changes
- The first titration regarded as final
- Data not recorded immediately after readings were made
- Correct number of decimal places for the burette reading not considered

- Funnel not used for transferring solution into burette
- The funnel not removed from the burette before reading the volume

Those who confirmed to have done less than five titrations seemed to know to some extent that:

(i) the burette should be rinsed with distilled water and the base to be used in it

(ii) the reading should be done at the bottom of the meniscus, and

(iii) any trapped bubbles of air from the burette should be removed.

However, it seemed from Table 5, that doing more titrations might have allowed these ideas to become more entrenched as part of the students' laboratory techniques.

The few students selecting the pipette for use in measuring the volume of the base, implied that, in general, students might not be conversant with the operation of the pipette. It could be that they did not use it in their laboratory work. Thus they intended to use the measuring cylinder with which they were familiar even though they were told to be as accurate in their work as possible.

Also majority of the students who chose the beaker for the titration might have had difficulties in swirling or stirring the solution in the beaker. Those who tried to swirl it spilled some of the solution while some of those who stirred with a glass rod could not mix the solution well. Those who spilled part of the solution while swirling the beaker did not attempt to repeat the titration run in order to obtain a more accurate endpoint. It seemed as if the choice to use the beaker was dictated by the fact that this was what they had been using in their laboratory work. Similarly, the choice of funnel for transferring solutions seemed to be influenced by the experience of the student with laboratory titrations.

The failure on the part of most of the respondents (60%) to repeat their titrations suggested that these students might have the notion that one observation of a phenomenon might adequately represent the phenomenon.

Tables 5 also shows that in performing the titration, almost all students were able to set up the experiment, added drops of the indicator to the acid in the flask before commencing the addition of base and constantly shook the titrating flask during the titration. However, 53.3% of the students overran the endpoint because they did not exercise caution in the addition of base as they approached the endpoint. Total of 66.7% did not also use a white background tile to detect the colour changes in the solution. Also, about half of the respondents did not record their readings until they were asked to do so. In recording their readings, it was noteworthy that about a quarter of the respondents did not read the burette to even one decimal place. This is despite the fact that the burette was graduated in such a way that the first decimal place could be obtained accurately while the second decimal place could be estimated and the uncertainties calculated. It seemed most of the students (66.7%) avoided estimating the uncertainty involved by recording their results to only one decimal place. It could also be that this was the normal practice in the school.

A large number of the respondents (80%) did not see the need to use the distilled water supplied in the wash bottle to wash down the acid dripping on the sides of the flask or beaker into the main body of the solution. This suggested that they had probably never employed it in their titrations. Some of the stusdents indicated that the students were not allowed by their teachers to use the wash bottles because they used it to squirt water on each other in the laboratory.

Thus, it seemed that above a certain degree of involvement in laboratory titrations, the students' psychomotor skills improve while below this number of involvements, these skills are not well developed.

In general, it could be concluded from the above results that the adequacy of the manipulative skills of the subjects in the study varied. That is, while appropriate manipulative skills were shown in some areas, e.g. setting up the experiment, adding indicator to the base before titration, shaking the conical flask constantly and inappropriate skills were displayed in other areas, e.g. overshooting the endpoint and not flushing the acid solution on the inside walls of the flask. It could be that this variation reflects the relative emphases placed by teachers on these techniques or the correct teaching techniques needed to be implored.

4.2.2 The effect of the STAD on the students' performance on titrimetric analyses

The analysis of results from Tables 6, 7 and 8 of the study revealed that there was an improvement in the pre-intervention mean score over the post- intervention mean score by 29.5 as indicated in Table 8. The performance of the students after the intervention indicated that the intervention process was very successful. This might have resulted from the exposure of the students to the use of the STAD. This strongly confirmed the findings that, the use of relevant learning strategies allow students to actively process information, thereby influencing their mastery of material and subsequent academic achievements (Pintrinch, Ryan & Patrick, 1998).

Student Teams-Achievement Divisions (STAD) learning model implemented in teaching and learning of titrimetric analyses provided activities which were useful to students in improving their motivation in learning. Through the activities in Student Teams-Achievement Divisions (STAD) group, there were some improvements of students' motivation in learning and made students' interest in the lesson to become higher. The students paid more attention to the lesson and teacher's explanation. During the teaching learning activities, the students were more actively involved in each activity. The students became brave to ask questions when they have difficulties. They liked and enjoyed to sit, study, and discuss the material. They got closer to their friend and interacted with them cordially in group work.

Also, through group interactions, such as the use of the STAD, learners got the opportunity to share ideas and provided feedback to each other, as well as made use of different perspectives and alternatives in learning (Mills, 2002). In Gillies' (2003) view, situations where students assisted their peers to learn through explaining topics to each other have been correlated with high academic achievement. This was experienced in the case of the present study where students who did not understand concepts contacted their colleagues for assistance. On knowledge retention, higher concept gain and knowledge retention of students involved in small group activities was better than those who performed only in competitive or individualistic environments (Mills, McKittrick & Feteris, 1999).

The findings suggest that, small group learning could be used to assist pupils to find solutions to problems in science even in deprived areas. Potthast (1999) also mentioned that, using a series of small groups in learning experiences increased students' scores on tests as compared to a group not using small group format. The findings also gives credence to Freedman's (2002) assertion that, participating in cooperative groups during scientific investigations had positive effects on attitudes and achievement levels for students.

4.2.3 The views of the students on the use of the STAD to teach titrimetric analyses

The results and the analyses of the data from Tables 9, 10 and 11 of the study revealed that the students had very good perceptions concerning the use of the STAD as teaching and learning strategy. Students confirmed the fact that the STAD as technique for teaching and learning was not boring and made them participate actively in the lesson. This agreed with the findings that learning was considered an active process and not a passive observation, and that learning in groups could reduce boredom in students thereby making the teaching and learning process to be much more interesting and enjoyable (Kundu & Tutoo (2004). This finding also supported the contemporary belief in science education that learners need to be active learners rather than passive recipients of scientific concepts to be learnt meaningfully (Kwang, 2002). This implies giving learners' opportunity to acquire direct learning experiences through active participation in group.

On the other hand, Mills (2002) stressed that, there is evidence that, high achieving students often dislike group work due to their dependence on others to obtain marks. However, there was no sign of resentfulness by very good pupils in the various groups in this present study.

There was willingness by all students to come to the classroom with a strong readiness to work in smaller groups. This commitment to work created a bonding among the pupils which in turn leads to higher academic self-esteem and positive feelings towards peers and the teacher. Small group learning experiences are preferred by students compared to competitive, individualistic and most traditional instructional methods (Johnson & Johnson (2009). Opportunities for science learning arise when children attempt to reach consensus as they work together (Barnes & Todd, 1997). In this situation, each student was obliged to explain and justify the observations made to the group and to listen to the explanations of other members in the group before a consensus was built. The STAD approach seemed to make students understand scientific concepts better. The learning setting provided students with greater opportunity to work through engaging with each other in an interactive way. They also learned to treat each other with respect and appreciate the contribution of others, speaking clearly, turn taking, and giving time to make points. This was true regardless of differences in ability level, sex, ethnic membership or task orientation. On a whole the students had positive perceptions concerning the use of the STAD in teaching and learning of the titrimetric analyses.

4.2.4 The differences in the performance of male and female students on titrimetric analyses using the STAD as the intervention

The mean difference of the two gender test scores from Table 15 were 42.5 and 25.2 for female and male respectively. Though it was clear that the mean scores for the post-intervention tests were greater than the mean scores for the pre-intervention tests in each case as indicated in Table 13 and 14 that of the female has been greatly improved as compared to that of the male. Thus, the mean difference (42.5) for female respondents was greater than the mean difference (25.2) for male respondents as shown in Table 15.

These findings of the results were incongruence to the study that came out with a finding that male students and female students did not differ significantly in their subjective task values toward accounting as a subject area (Xiang, McBride & Bruene, 2005, 2006). But the results were in line with the findings which proved that gender differences among students was as a result of perceived gender appropriateness of the activities performed (Solomon, Lee, Belcher, Harrison & Wells, 2003). This implied that when students were engaged in works deemed as gender appropriate, their expectancy-related beliefs tend to grow.

It was noted that, the male students performed better than females in the pre-intervention results. This finding confirmed a study on gender differences in performance between male and female students which revealed that, males' performances outweighed those of females in a business class (Udoukpong, Emah & Umoren, 2012) but contradicted the results which asserted that female students in the U.S. perform better than their male counterparts in mathematics performance (Hyde & Mertz, 2009). Also, it was found out from a study that females rather perform better than their male counterparts in the first year accounting which was undertaken via distance learning which was full of social interaction among the students during the third year of the programme (Gammie, Paver, Gammie & Duncan, 2003).

The mean difference of the post-intervention result outweighing that of the post-intervention results of the male did not come as a surprise as a result of the STAD but confirmed the fact that education and training in workshops, cooperative learning and science clinics boosted the morale of girls and increased the level of creativity and discoveries and succeeded in breaking some of the myth surrounding science and technology (Awortwi & Korang-Okrah, 2007). Females are naturally more sociable than the males counterpart in almost all social settings thereby contribute more effectively anytime appropriate classroom activities give them the opportunity. This assertion confirmed the findings of Narrow (2008), who reported that, team work and collaboration was beneficial to female students. During the use of the STAD, female students were more socially interactive in their teams than their male counterpart hence the improved results.

In a similar vein, the current study is in line with the research results which revealed that students regular class attendance, use of teaching and learning materials, students motivation and above all cooperative learning are all significantly related to success in a subject area especially on the part of the female student (Kutnick, Ota, & Berdondini, 2006). This was the reason why though in the pre-intervention result males performed better than the females, but this notwithstanding, the females did better than the males after the used of the STAD.

CHAPTER FIVE

SUMMARY, CONCLUSION, RECOMMENDATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

5.0 Overview

This chapter presents a summary of the key findings that arouse from the study. The chapter also contains the conclusions and recommendations that were made based on the findings of the study. It again suggests areas for further research.

5.1 Summary of the Key Findings

The driving force of this research was to use Student Team Achievement Division to improve the performance of students on titrimetric analyses in Breman Asikuma SHS. Specifically, the study aimed at examining: the difficulties students encounter during theory and practical lessons on titrimetric analyses, the effect of the STAD on the students' performance on titrimteric analyses, the views of the students on the use of the STAD to teach titrimetric analyses and the differences in the performance of male and female students on titrimetric analyses using the STAD as the intervention. The study adopted a case study design using the action research approach. The study targeted population comprised of all form two chemistry students in Breman Asikuma Senior High School during the 2018/2019 academic year. This study therefore adopted purposive sample type to select the two intact classes of form two science students in Breman Asikuma Senior High School totaling ninety-five (95) as a sample for the study. They were made up of fifty- five (55) males and forty (40) female. Descriptive statistics (means, standard deviation, frequencies, and percentages) was used to analyse the research questions to find out the mean performance of the students. The key findings of the study were done considering each of the research questions.

The researcher first identified a number of difficulties that second year science students of Breman Asikuma encountered during theory and practical lessons on titrimetric analyses that affected their performance in the pre-intervention scores under category A, B and C.

5.1.1 Difficulties of Scientific Terminologies Associated With Titrimetric Analyses

The students showed an inadequate understanding of the terms: endpoint and stoichiometric point even though they used them frequently.

5.1.2 Difficulties with Indicator Behaviour

Most of the students were found to show an understanding of the function of indicators in acid-base titrations. However, in selecting indicators for titrations, most students did not relate the pH range of the indicator to the stoichiometric point for the reaction under study. Most of the explanations offered related to their own laboratory experiences. In the case of the titration of a strong acid with a strong base, the students did not realize that the wide range of pH change at the stoichiometric point allows for the use of a wide variety of indicators.

Most of the students were also found to view indicators as neutral substances whose relative volume does not affect the titration results. In trying to explain the colour changes which occur in titration only 26.6% of the students referred to the equilibrium between the dissociated and undissociated forms of the indicator.

5.1.3 Difficulties with manual skills in the laboratory

The analysis of the practical skills of the interview with students showed that the adequacy of their skills varied with the specific skill in question. Thus, whereas most students exhibited satisfactory skills in setting up the experiment and adding an indicator before titration, an equally large number of them failed to exercise caution when adding the basic solution to the acid, shaking the titration flask or to use a white background to aid in detecting the colour changes of the indicator. This situation was attributable to the different emphases placed on the various manual skills by individual teachers.

A further analysis of the manual skills in terms of the degree of involvement in practical laboratory titrations showed that above a certain degree of involvement satisfactory manual skills were displayed by the students while below this number the skills were not as well developed.

5.1.4 Differences in students' performance in the overall pre-intervention test score and overall post-intervention test score

The analysis of the mean difference of the students overall pre and post-intervention scores revealed that their performance in in titrimetric analyses had improved significantly due to the use of the STAD. However, a look at the percentage of students who gave wrong responses to the various items in the post-intervention test suggested the use of other teaching techniques and aids along the STAD.

5.1.5 Students' views on the use of the STAD

Students' perceptions were found to be positively related to their performance. From the study, the students showed high appreciation towards the use of the STAD as a cooperative teaching and learning technique in teaching and learning of titrimetric analyses. Their appreciation motivated them to participate actively which in turn helped them improve upon their knowledge about the titrimetric analyses.

5.1.6 Difference in the performance in the overall pre-intervention test score and overall post-intervention test score of female and male students

The males performed better than the females in the pre-intervention whereas the females performed better in the post-intervention than the male. The mean of (M=35.0) and (M=27.0) of the male and female students respectively in the pre-intervention showed that male students performed better than female students. The mean of M=60.2 and M =69.5 of the male and female students respectively however showed that the female performed better than the male students in the post-intervention after the used of the STAD. The used of the STAD was seen as the main factor which made the difference in the performance after the intervention.

5.2 Conclusion

The study revealed that Breman Asikuma Senior High School science students used in this study had not developed an appropriate conceptual understanding of the theory and practical titrimetric analyses hence encountered a lot of difficulties on the terminologies, indicator behaviour and manual laboratory skills in titrimetric analysis before the intervention. The findings lent credence to Anamuah-Mensah (1981) statement that students often lacked deep conceptual understanding and had difficulties with key concept connected with volumetric analysis if the appropriate measures were not taken.

The use of the STAD was very effective and successful because it had improved the performance of the students on the titrimetric analyses.

Finally, the research findings indicated that, the students had an overall positive perception concerning the use of the STAD. It was suitable for heterogeneous groups of age, sex, ability level and above all ethnicity. It also facilitated individual and group learning and could be used with little or no assistance of the teacher. Students were therefore motivated to participate actively during the use of the STAD in the intervention.

5.3 Recommendations

Considering the findings and conclusions drawn from the study, the following recommendations have been made for consideration:

- That, the STAD approach was effective as a technique for enhancing students' understanding and retention of titrimetric analyses concepts in science and so chemistry teachers in the school must endeavour to follow the suggested steps to use the STAD in teaching chemistry topics or incorporate it in any other method of teaching in order for the students in the school to reap the benefit.
- The students should work together, they should be able to helps each other and keep togetherness among the team members. Beside in the classroom, they should apply the activities in the other place and in other times.
- Also, the poor understanding and difficulties shown on scientific terminologies, indicator behaviour and the inadequate manual skills displayed by the respondents points to the need for teachers to examine the objectives that they may have for practical work and whether these are communicated well to the students. There should be a move away from the highly prescriptive "cook-book" laboratory which occurs mostly in the school to a less prescriptive type. The adoption of the less prescriptive type may help students to understand the

possible implications and explanations of their actions and observations during practical work. This type of practical work may require the students to make decisions on their own in the selection of equipment and solutions for practical work. It is to be hoped that these decisions would tend to be based on a sound chemical knowledge rather than on the students' familiarity with the equipment or solutions. The chemistry teacher can facilitate this process through asking questions (such as those used in the interview) which can identify the students' reasoning at various stages in the investigation. In order to provide ample time for chemistry teachers to effect this less prescriptive approach, it seems that chemistry instruction in the Breman Asikuma Senior High School may have to move away from the encyclopedic coverage of the concepts to teaching fewer concepts for greater conceptual understanding. The onus may also be placed on curriculum writers. They also have to move away from the usual practice of providing "cook-book" type experiments in laboratory texts written for students.

5.4 Suggestions for future research

- This study discussed the implementation of Student Teams-Achievement Divisions (STAD) technique to improve the performance of students on titrimetric analyses in Breman Asikuma SHS. It was conducted on the senior high school students. The researcher hopes that this technique can be applied by other researchers in different level of education.
- This study was carried out in Breman Asikuma Senior High School of a sample size of ninety-five (95) students. A larger scale study should be carried out to compare the effectiveness of the STAD on students' performance on titrimetric analyses or any other concept in science from other SHS in the country as a

whole. That the use of larger samples could give a wider view on the use of the STAD.

- The writer hopes that the finding of this study will be used as starting point of the future research on similar problems.

REFERENCES

Abimbola, I. O. (1994). A critical appraisal of the role of laboratory chemistry practical in science teaching in Nigeria. *Journal of Curriculum and Instruction*, *4* (1&2), 59-65.

Acar, B., & Tarhan, L. (2008). Effects of cooperative learning on students understanding of metallic bonding. *Research in Science Education, 38*, 401-420.

Achor, E. E., Kurumeh, S. M., & Orokpo C. A. (2012). *Gender dimension in predictors of students' performance in mock-ssce practical and theory chemistry examinations in some Secondary Schools in Nigeria*. California, USA: Scientific & Academic Publishing Co.

Adesoji, F. and Ibraheem, l. (2009). Effects of student teams-achievement division strategy and Mathematics knowledge on learning outcomes in chemical kinetics. *Journal of Chemical Kinetics, 2,* 506-676.

Aina, J.K. (2012) Gender inequality in science enrolment and academic performance in nigeria schools. *Academic Educational Journal, 2*(2), 233-321.

Alireza, K. K. (2009). The effect of cooperative learning technique on college students' reading comprehension. *American Research Journal of English and Literature*, *2*(1), 20-39.

Amedahe, F. K. (2002). *Fundamentals of educational research methods.* Cape Coast: University of Cape Coast.

Ameyibor, K., & Wiredu, M. B. (2001). *Chemistry for senior secondary schools*. Accra: Unimax Macmillan.

Amoani, K. (2005). *Research methodology and review.* Accra: Pentecost Press.

Anaekwe, M.C. (1997). *Effects of students' interaction patterns on cognitive achievement, retention and interest in chemistry*. Doctoral Dissertation, Nsukka: University of Nigeria.

Anaekwe, M.C. (2006). Application of cooperative learning and concept mapping as instructional strategies in science teaching and learning. *Workshop by science teachers association of Nigeria, 3,* 128-324.

Anamuah-Mensah, J. (1981). *Student difficulties with volumetric analysis*. Bogota: University of British Columbia**.**

Anto, J., Padmadewi, & Putra (2013). The effect of stad technique and learning motivation toward the students' reading competence. *Electronic Journal Program Pasca Sarjana Universitas Pendidikan Ganesha. 1*(2), 241-432.

Asamoah, R. (2013). *Brightest and best practical chemistry for West African senior high schools.* (3rd ed.). Kumasi, Ghana: Benjoy Enterprise.

Awortwi, S. & Korang-Okrah, R. (2007). Successes and challenges of the girl-child. *Gender Matters 1*, 1 – 3

Babajide, V.F.T. (2010). *Generative and predictive observe-explain instructional strategies as determinants of senior secondary school students' achievement and practical skills in physics.* Ph.D. thesis. University of Nigeria, Nsukka.

Balfakih, N.M.A. (2003). The effectiveness of student team achievement division (STAD) for teaching highschool chemistry in the United Arab Emirates.International. *Journal of Science Education, 5*(5):605 – 624.

Barnes, D., & Todd, F. (1997). Communicating and learning in small-group. *Journal forResearch in Mathematics Education, 22*(5), 390-408.

Basilli, P. A., & Sanford, J. F. (1991). Conceptual change strategies and cooperative group work in chemistry. *Journal of Research in Science Teaching, 28*(4), 293-304.

Baubeng, I., Osei, A. T, & Ampiah, G. J, (2014). *An investigation into Physics teaching in senior high schools Journal of physical science 2* (1), 102-233.

Bennett, J. (2003). *Teaching and learning science.* London, England: The Continuum International Publishing Group Ltd.

Bogdan, R. C., & Biklen, S. K. (2007). *Qualitative research for education: An introduction to theory and methods (5th ed.).* Boston, MA: Allyn & Bacon.

Bosede, A.F. (2010). Influence of sex and location on relationship between students problems and

Cardak, O., Onder, K. & Dikmenli, M. (2007). Effect of the usage of laboratory method in primary school education for the achievement of the students' learning. *Asia-Pacific Forum on Science Learning and Teaching*, *8*(2), 3- 87.

Castillo, J. J. (2009). *Research population*. *International Social Journal, 3,* 355-432.

Chepkorir, S, Cheptonui, M. E, & Chemutai, A. (2014). The relationship between teachers' related factors and students' attitudes towards secondary school chemistry subject in Bureti district, Kenya. *Journal of technology science and education, 1* (3), 231-324.

Cohen, E.G., Broody, C.M., & Sapon-Shevin, M. (2004). *Teaching cooperative learning: the challenge for teacher education*. Albany: State university of New York press.

Cohen, L., Manion, L., & Marrison, K. (2007). *Research methods in Education* (6th ed.). London: Routledge

Cohen, L., Manion, L., & Morrison, K. (2008). *Research methods in education.* New York, NY: Routledge.

Cole, M., Janes, R., Mclean, M & G. Nicolas, G. (1998). Educational research. *Journal of Education 3 (*5): 56-78.

Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (4th ed.). Boston, MA: Pearson.

Dahlgren, L.O., & Marton, F. (1998). Student conceptions of subject matter. *Studies in Higher Education, 3* (1), 25-35**.**

Denscombe, M. (2010). *Ground rules for social research guidelines for good practice.* Berkshire, UK: Open University Press.

Dingrando, L., Gregg, K.V., Hainen, P. & Wistrom C. (2002). *Chemistry: matter and changes* (5^{th} ed.). New York: Glencoe.

Dorin H. (2009). *Chemistry: the study of matter* (5^{th} Ed.). Newton MA: Allyn and Bacon
s

Dusick, D. M. (2011). Writing the delimitations. *Research Journal, 2,* 345-541.

Duyilemi, A.N. (2005). The jets programmes and the attitude of girls to education, and gender sensitive classrooms. Science teachers association of Nigeria. *Gender and STM Education series 2*(2), 5-8.

Eminah,J.K. (2008). *Practical chemistry for senior high schools*. Accra: Masterman Publications Ltd

Eze, C. C. (2010). Repositioning chemistry education in Nigerian Colleges of Education for Economic empowerment. *51st Annual conference proceedings science teachers association of Nigeria (STAN).* 287-292

Ezeh, D.N. (2013). *Writing research proposal and report without tears: Prior knowledge, exploratron discussion dissatisfaction.* Lagos, Nigeria*:* Ephrata Publishers.

Ferrance, E. (2000). *Action research: education themes, national and regional educational laboratory.* Providence Rhode: Brown University.

Fraenkel, J. R., & Wallen, N. E. (2000). *How to design and evaluate research in education.* London: McGraw-Hill.

Freedman, S. W. (2002). *Inside city schools: investigating literacy in multicultural classrooms.* New York: Teachers College Press.

Gabel, D. L. (1999). Improving teaching and learning through chemistry education research: A look to the future. *Journal of Chemical Education, 76*(4), 584-554.

Gammie E., Paver, B., Gammie, B., & Duncan, F. (2003). Gender differences in accounting education: An undergraduate exploration Accounting Education. *An International Journal*, *12* (2), 177-196.

Gillies, R. M. (2003). The effects of cooperative learning on junior high school students during small group learning: Learning and instruction. *Journal of Education Psychology, 14*(2), 197-213.

Glomo-Narzoles, D.D. (2015). The implementation of the cooperative learning method in teaching reading comprehension, *American Research Journal of English and Literature, 8* (5), 200-278.

Gunstone, R.F., & Champagne, A. B. (1990). Promoting conceptual change in the laboratory. In E. Hegarty-Hazel (Ed.). *The student laboratory and the science curriculum* (pp. 346-458). London: Routledge.

Gunter MA, (2003). *Instruction: A models approach* (4th ed.). Boston: Allyn & Bacon.

Hagen, J. P. (2000). Cooperative learning in organic chemistry: Increase retention on a commuter campus. *Journal of Chemical Education, 77*(11), 1441-1444.

Hannan, A. (2007). Questionnaire in education research. *Journal of University of Plymouth, 1*(2), 221-238.

Hanson, R. (2017). Enhancing students' performance in organic chemistry through context-based learning and micro activities. *European Journal of Research and Reflection in Educational Sciences 5* (6) 56-89.

Hofstein, A. & Mamlok-Naaman, R. (2007). The laboratory in science education: the state of the art. *Chemistry Education Research and Practice, 8*(2), 105-107.

Hofstein, A. (2004). The laboratory in chemistry education: Thirty years of experience with developments, implementation, and research. *Chemistry Education: Research and Practice*, *5*(3), 247-264.

Hyde J. S., & Mertz, J. E. (2009). Gender, culture, and mathematics performance. *Proceedings of the National Academy of Sciences. 106*, 8801–8807.

Ifeakor, A.C. (2006). Situational assessment of computer assisted instruction package as a strategy for the teaching and learning chemistry in secondary schools: Achieving the gold standard. *Workshop by Science Teachers Association of Nigeria, 2*(2), 234-678.

Ikeobi I. O. (2010). *Beyond the stereotype thoughts and reflections on education*. Kanu: The CIBN Press Ltd.

Jack, F. R., & Norman, E. W. (2003). *How to design and evaluate research in education (5th ed.).* Boston: McGraw Hill Publishers.

Jegede, A. (2007). Inculcation of practical skills in Students and Teachers. *Journal of STAN Proceedings of the 48th Anniversary conference, 21(2), 342-456.*

Johnson, D. W., & Johnson, R. T. (2009). An educational psychology success story – social interdependence theory and cooperative learning. *Educational Researcher, 38*(5), 365-377.

Khan, G. (2011). Effect of student's team achievement division (STAD) on academic achievement of students. *Journal Group Teaching, 3*(1),58-102.

Kudu, C. & Tutoo, D. C. (2004). *Educational psychology*. New Delhi: Sterling Press.

Kusi, K. (2013) - *Improving the performance of students' in titrimetry through cooperative learning in senior high schools within Kumasi*. (Unpublished Master's Thesis). University of Education, Winneba.

Kutnick, P., Ota, C., & Berdondini, L. (2006). Improving the effects of group working in classrooms with young school-aged children: Facilitating attainment, interaction and classroom activity. *Learning and Instruction, 18*, 83-95.

Kwang, T. (2002). An investigative approach to mathematics teaching and learning. *The Mathematics Educator, 6*(2), 32-46.

Ling, T. A., & Towndrow, P. A. (2010*). Giving students a voice in science practical assessments.* Singapore: National Institute of Education Press.

Lunetta, V. N., Hofstein, A., & Clough, M. P. (2007). Teaching and learning in the school science laboratory. An analysis of research, theory, and practice. In, S. K. Abell and N. G. Lederman (Eds), *Handbook of Research on Science Education* (pp. 393–431). Mahwah, NJ: Lawrence Erlbaum Associates.

Martins-Umeh, N.F. (2009). Co-operative learning approach and sociology. *African research review***,** *3*(3) 389 – 398.

Miller R. (2004). *The role of practical work in teaching and learning science.* Washington, D.C.: Sound Press Ltd.

Mills, B. J. (2002). Fulfilling the promise of the 'seven principles' through cooperative learning: Action agenda for the University Classroom. *Journal on Excellence in College Teaching, 2*, 139-144.

Mills, B., Mckittrick, P., & Feteris, S. (1999). Cooperative learning that works. *Physical Education, 34,* 11-16.

Ministry of Education, Science, and Sports [MOESS]. (2010). *Teaching syllabus for chemistry. Senior high school 1-3.* Accra: Curriculum Research and Development Division.

Muhammad, B.A. (2014) An evaluation of the efficacy of conceptual instructional method of teaching practical chemistry: The case of secondary schools in Zaria Educational zone Kaduna State, Nigeria. *African Journal of Education and Technology, 4*(1), 12-118.

Narrow, S. (2008). Attitudes towards science and mathematics. A review of the literature and its implications in schools. *International Journal of Education, 25*(9), 1039-1045.

Njoku, Z. C. (2003). Development and preliminary validation of a scale for the assessment of students interest in O level practical chemistry activities. *Journal of the science Teachers Association of Nigeria*, *38*(1), 64-70.

Njoku, Z.C. (2009). Enhancing the relevance of chemistry curriculum delivery using science – Technology. *Proceedings of the African Regional Conference of International council of Associations for Science Education. 1,* 48 – 54.

Norman,D. G. (2005). Using STAD in an elementary school classroom in South Korea: effect of student achievement, motivation and attitude towards cooperative learning. *Asian EFL Journal. 1*(1), 112-232.

Ogunleye, B.O. & Babajide V.F.T. (2011). Commitment to science and gender as determinant of students' achievement and practical skills in physics. *Journal of the Science Teachers Association of Nigeria (STAN), 46*(1), 125-135.

O'leary, A. (2004). *The essential guide to doing research.* London: SAGE Publications.

Omolade, O. O. (2008). Effects of lecture demonstration and lecture teaching methods on students' achievement in secondary school chemistry. *Journal of Teacher Education, 9*(10), 175-212.

Omwirhiren, E.M. (2008). The effect of practical skills on achievement in practical chemistry among selected secondary schools in Zaria metropolis. *Nigerian Journal of Professional Teachers, 1*(5), 40-51.

Omwirhiren, E.M. (2012). An Investigation into the relative effectiveness of laboratory and lecture instructional strategy on students' achievement and retention in some selected topics in SSCE chemistry. *Sardauna Journal of Multi-disciplinary Studies*, *3*(1), 207-213

Parson, R. D., & Brown, K. S. (2002). *Teachers as reflective practitioners and action researchers.* Belmont Calif: Wadsworth/Thomson learning.

Patton, M. Q. (2002). *Qualitative evaluation and research methods* (3rd ed.). Thousand Oaks, CA: Sage Publications Inc.

Pintrinch, P., Ryan, A. M., & Patrick, H. (1998). The differential impacts of task value and mastery orientation on males' and females' self-regulation learning. *Institute for Science Education, Interest and learning, 3*(1), 337–354.

Potthast, M. J. (1999). Outcomes of using small group cooperative learning experiences in introductory statistics courses. *College Student Journal, 33*(10), 34-42.

Punch, K. (2006). *Introduction to social research: Quantitative and qualitative approaches.* Thousand Oaks, CA: Sage.

Punch, K. F. (2006). *Developing effective research proposals (2nd ed.).* London: Sage Publication.

Rai, N. (2007). STAD Vs Traditional teaching, redesigning pedagogy –conference *Journal of teaching pedagogy, 3*(1), 266-340.

Rose L.R. (2014).*The effects of a cooperative learning strategy on post-secondary students' mathematics achievement*. Masters' Thesis. Department of Curriculum and Instruction State University of Fredonia, New York.

Schul J.E. (2011) Revisiting an old friend: The practice and promise of cooperative learning for the twenty-first century. *The Social Study.10* (2), 88-93.

Silberberg, M.S. (2007). *Principles of general chemistry* (2nd ed.) New York, NY, America: McGraw-Hill Companies, Inc.,

Simon, M. K., & Goes, J. (2013). *Dissertation and scholarly research: Recipes for success.* Seattle, WA: Dissertation Success LLC.

Slavin, R. E. (1997). Development and motivational perspective on collaborative learning. *Reconciliation Child Development, 58*, 1161-1167.

Slavin, R.E. (1996). Research for the future: Research on cooperative learning and achievements *Contemporary Educational Psychology, 2*(1), 43-69.

Solomon, M. A., Lee, A. M., Belcher, D., Harrison, L. Jr., & Wells, L. (2003). Beliefs about gender appropriateness, ability, and competence in physical activity. *Journal of Teaching in Physical Education, 22,* 261–279.

Ssempala, F. (2005). *Gender differences in performance of chemistry practical skills among senior six students in Kampala District*. PhD thesis, University of Boca Raton, Florida, USA

Tan, A-L. (2008). Tensions in the biology laboratory: What are they? *International Journal of Science Education, 30*(12), 1661–1676.

Trochim, W. M. (2006). Research methods. *Social Research Methods*. *12*, 141-235.

Twoli, N.W. (2006). *Teaching secondary school chemistry.* Nairobi, Kenya: Nehema Publishers.

Udoukpong, B. E., Emah, I. E., & Umoren, S. E. (2012). Business studies academic performance differences of secondary school juniors in AkwaIbom State of Nigeria. *International Education Studies, 5* (2), 35-43.

Umoh, C.G. (2003). A theoretical analysis of the effects of gender and family education on human resources development. *Journal of Curriculum Organization of Nigeria, 10(1), 1-4.*

Wellington, J. (1998). *Practical work in school science. Which way now*? London: Routledge.

West Africa Examination Council (WACE) (1998-2015). *Chief Examiners' Report- Chemistry.* Accra: West African Examinations Council.

West Africa Examination Council (WACE) (2013-2017). *Chief Examiners' Report- Chemistry.* Accra: West African Examinations Council.

Wilbraham, A. C., Staley D. D & Matta, M. S., (1996). *Addison- Wesley chemistry* Menlo Park: Academic Publishers.

Woolnough, B. (1991). *Practical science.* Buckingham: Open University Press.

Xiang, P., Chen, A., & Bruene, A. (2005). Interactive impact of intrinsic motivators and extrinsic rewards on behavior and motivation outcomes. *Journal of Teaching in Physical Education, 24,* 179–197.

Xiang, P., McBride, R., & Bruene, A. (2006). Fourth graders' motivational changes in an elementary physical education running program. *Research Quarterly for Exercise and Sport, 77,* 195–207.

Yin, R. K. (2003). *Case study research: Design and methods.* Thousand Oaks, CA: Sage.

Yockey J.A (2001). *A key to science process skills*. London: Routledge.

Zohrabi, M. (2013). Mixed method researcher: Instruments, validity, reliability and reporting findings. *Theory and Practice in Language Studies 3*(2), 254-262.

APPENDIX A

ACHIEVEMENT TEST ON TITRIMETRIC ANALYSIS

(PRE- INTERVENTION TEST 1)

Please provide answers to the following items. These questions are meant for research work and marks obtained will NOT be used against you.

Sex ………….. Age…………

Date ………………………… Duration: 60mins.

Name of School: ……………………………………………………….

Instruction: Fill in the blank spaces provided.

ANSWER ALL QUESTIONS

TOTAL OF 50MARKS

Some Terminologies Associated with Titrimetric Analysis

SECTION A

.

(1). Explain the term **titration…**……………...**[1 mark]**

(2). What is meant by **acid-base titration?.. [1 mark]**

(3). Give **two (2)** examples of acid-base titrations……………………..….**[2 marks]**

4) What **physical criteria** would you use to determine the completion of titrimetric process? ……….........................…………………………………………….. **[1 mark]**

APPENDIX A CONTINUED

SECTION B

INDICATORS

(1). What is meant by an **acid-base indicator**?..**[1 mark]**

(2). Complete the table below:-

Indicator	**Colour in acid solution**	**Colour in alkali solution**	**Colour in neutral solution**
Phenolphthalein			
Methyl Orange			

[6 marks]

SECTION C

Skills Acquisition on Titration / Titrimetric / Quantitative Process

(1) (a). State **three (3)** precautions that should be taken to avoid errors that may be introduced into titration measurements.

i)…………………………… ………………..…………………………………………

ii)…………………………..……………………………………………………………

iii)………………………………………..………………………………………………

[3 marks]

(b) In an *acid-base titration*, which of the substances is usually put in the:-

(i). Burette………………………………………

(ii) Pipette………………………………………

[2 marks]

APPENDIX A CONTINUED

(2). Explain the following terms:-

(a). **Consistent titre**………………………………………………………… [**1 mark]**

(b).**Titre value**……………………………………………………………. **[1 mark]**

(3). Find the **consistent titres** from the following values and determine their **average titres**

(i) 20.80, 20.50 and 0.40……………………………………………….. **[1 mark]**

(ii) 18.50, 18.80 and 18.50………………………………………..………. **[1 mark]**

SECTION D

Balancing Simple Chemical Equations

(1). Complete and balance the following chemical equations:-

(a). NaOH + HCl → ………………………………………………

(b). Na_2CO_3 + HCl → ……………………………………………

(c). Na_2CO_3 + H_2SO_4 → ……………………………………………

[9 marks]

(2). Complete and balance the following equations:-

(a). HCl + BOH → ……………………………………………………

(b). HNO_3 + $M(OH)_y$ →……………………………………………………..

[6 marks]

APPENDIX A CONTINUED

SECTION E

APPROACHES USED IN THE COMPUTATION OF SOLUTION CONCENTRATION

1. The following table gives the burette readings when 20.00cm^3 portions of 0.100moldm^{-3} solution of sodium hydrogen trioxocarbonate (IV), $NaHCO_3$ were titrated against dilute trioxonitrate (V) acid, HNO_3 using methyl orange as indicator.

The equation for the reaction is $\mathbf{NaHCO_{3(aq)} + HNO_{3(aq)} \rightarrow NaNO_{3(aq)} + CO_{2(g)} + H_2O_{(l)}}$

Burette readings/ cm^3	1st titration	2nd titration	3rd titration
Final burette readings/cm^3	22.00	41.20	29.20
Initial burette readings/cm^3	1.10	21.10	9.30
Volume of acid used/cm^3			

i) Copy and complete the table. **[4 marks]**

ii) Calculate the average titre. **[2 marks]**

iii) Determine the concentration of the acid in moldm^{-3}. **[4 marks]**

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

APPENDIX B

TEST 2 (POST-INTERVENTION TEST)

Please provide answers to the following items. These questions are meant for research work and marks obtained will NOT be used against you.

Sex ………….. Age………

Date………………………………………… Duration: 60mins.

Name of School: ……………………………………………………….

Instruction: Fill in the blank spaces provided.

ANSWER ALL QUESTIONS

TOTAL OF 50MARKS

SECTION A

Some Terminologies Associated with Titrimetric Analysis

(1). Explain the following **titration or titrimetry** terms:-

(a).***Titrant***…………………………………………………………………………

(b). ***End point***…………………………………………………………………

(c).***Equivalence point***………………………………………………………...

(d).***Analyte***………………………………………………………………………

[4 marks]

APPENDIX B CONTINUED

SECTION B

INDICATORS

(1). Copy and complete the table below:-

Type of Acid-base Titration	Best indicator	Indicator's pH-range	Example of the reaction
Strong acid & Strong base			
Strong acid & weak base			
Strong base & weak acid			
Weak acid & weak base			

[12 marks]

SECTION C

Skills Acquisition on Titration / Titrimetric / Quantitative Process

(1). List **four (4)** main apparatus used for titration.

(a) ………………………………………………………………………

(b) ………………………………………………………………………

(c) ………………………………………………………………………

(d) …………………………………… ……………………………..

[4 marks]

(2). (a) State **three (3)** sources of errors that may be introduced into titration measurement. …………………………………………………………………… **[3 marks]**

(3). Find the **consistent titre** from the following values and determine their **average titres**

(i) 10.50, 10.50 and 10.40 ……………………………………………… **[1 mark]**

(ii) 27.50, 27.80 and 27.50 ……………………………………………… **[1 mark]**

APPENDIX B CONTINUED

SECTION D

Balancing Simple Chemical Equations

(1). Complete and balance the following chemical equations:-

(a). NaOH + HNO_3 → ....

(b). KOH + H_2SO_4 → ....

[4 marks]

(2). Complete and balance the following equations:-

(a). H_2Y + KOH → ....

(b). H_2SO_4 + $X(OH)_2$ → ....

(c). HNO_3 + $Na_2CO_3.xH_2O$ → ....

[6 marks]

SECTION E

APPROACHES USED IN THE COMPUTATION OF SOLUTION CONCENTRATION

(6). **G** is 0.10 moldm^{-3} HCl solution.

H is a Na_2CO_3 solution.

(a). Put **G** into the burette and titrate it against 20cm^3 or 25cm^3 portions of **H** using methyl orange as indicator. Repeat the exercise to obtain consistent titre values. Tabulate your results and calculate the average volume of the acid used. **[6 marks]**

APPENDIX B CONTINUED

(b). Write a balanced equation for the reaction in the titration. **[3 marks]**

(c). From your results and the information given, calculate the concentration of **H** in

(i). $moldm^{-3}$ (ii). gdm^{-3} **[6 marks]**

[H = 1.0, Cl = 35.5, O = 16.0, Na = 23.0, C = 12.0]

Solution:

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

APPENDIX C

MARKING SCHEME FOR BOTH PRE-INTERVENTION TEST AND POST INTERVENTION TEST ON TITRIMETRIC ANALYSIS

MAKING SCHEME FOR TEST 1 (PRE-INTERVENTION TEST)

SECTION A

(1). **Titration** is the process of used to determine the concentration of a substance (say solution A) by adding small, measured amounts in volume of a standard solution (solution B) with which it reacts. **1 mark**

(2). **Acid- base titration** is a process used to determine the concentration of the acid by adding small measured amounts in volume of a standard base solution with which it reacts. **1 mark**

(3). **Types of acid – base titration:**

a) Simple titration b) Back titration c) Double indicator Titration

Any correct two for 2 marks (1×2=2marks)

(4). The colour change of the indicator(s) used. **1 mark**

SECTION B

(1). **Acid- base indicator** is a weak acidic or basic organic substance which changes colour depending on the pH of the solution to which it is added. **1 mark**

(2).

Indicator	Colour in acid solution	Colour in alkali solution	Colour in neutral solution
Phenolphthalein	**Colourless**	**Red/Pink**	**Colourless**
Methyl Orange	**Red/Pink**	**Yellow**	**Orange**

1×6 = 6 marks

APPENDIX C CONTINUED

SECTION C

(1) (a) Precaution to be taken to avoid errors in titration measurement.

i) It must be ensure that correct volumes of solutions are measured and delivered by the pipette and burette.

ii) The titration mixture must be observed carefully in order to detect the slightest change in colour of the solution.

iii) It must be ensure that the funnel is taken of before initial burette reading is taken.

iv) Do not blow the last drop of solution at the tip of the pipette into the conical flask because the pipette is calibrated to give a fixed volume without the last drop.

v) Air bubbles in the pipette or the burette should be flushed out since it affects the volume delivered.

vi) Ensure that the tap of the burette is not lose to avoid leakage.

Any correct three for 3 marks **($1 \times 3 = 3$ marks)**

(b) i) Acid ii) Base **$1 \times 2 =$ 2 marks**

(2) a) Consistent titres are any two (2) or more titres which do not differ by more than $\pm$ 0.20cm^3. **1 mark**

b) It is the volume of solution from the burette which reacts with the stated volume of the other solution at the end point of the titration. **1 mark**

(3) i) 20.80, 20.50 and 20.40

Consistent titres :- 20.50 and 20.40

Average titre values:- $\frac{20.50+20.40}{2}$ = **20.45cm^3** **1 mark**

ii) 18.50, 18.80 and 18.50

Consistent titres:- 18.50 and 18.50

APPENDIX C CONTINUED

Average titre value:- $\frac{18.50+18.50}{2}$ = **18.50cm³** **1 mark**

SECTION D

(1). Balancing Simple Chemical Equations

(a). $NaOH + HCl \rightarrow NaCl + H_2O$

(b). $Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O$

(c). $Na_2CO_3 + H_2SO_4 \rightarrow Na_2SO_4 + CO_2 + H_2O$. **[× 3 = 9 marks]**

(2). Complete and balance the following equations:-

(a). $HCl + BOH \rightarrow BCl + H_2O$

(b). $HNO_3 + M(OH)_y \rightarrow M(NO_3)_y + yH_2O$. **[3 × 2 = 6 marks]**

SECTION E

1. i) Completed Titration Table

Burette readings/ cm³	1st titration	2nd titration	3rd titration
Final burette readings/cm³	22.00	41.90	29.20
Initial burette readings/cm³	1.10	22.10	9.30
Volume of acid used/cm³	**20.90**	**19.80**	**19.90**

2 × 3 = 6 marks

ii) Consistent titres: - 19.80 and 19.90

Average titre values: - $\frac{19.80+19.90}{2}$ = 19.85cm³ **2 marks**

iv) ***Concentration of the concentration of the acid in moldm⁻³***.

Balanced chemical equation

$HNO_{3(aq)} + NaHCO_{3(aq)} \rightarrow NaNO_{3(aq)} + CO_{2(g)} + H_2O_{(l)}$

1 mark

APPENDIX C CONTINUED

Mole ratio: $\frac{n(HNO_3)}{n(NaHCO_3)} = \frac{1}{1}$ **1 mark**

But n ($NaHCO_3$) = C × V = 0.100moldm^{-3} × 0.020dm^3 = 0.002mol **1 mark**

∴0.002mol of HNO_3 solution is contained in 19.85cm^3 (0.01985dm^3)

Since 19.85cm^3 (0.01985dm^3) contains 0.0020mol then 1000cm^3 (1dm^3) will contain

$= \frac{1000 \times 0.002}{19.85} = 0.100756$mol **1 mark**

C (HNO_3) = **0.101moldm^{-3}** **2 marks**

MARKING SCHEME FOR TEST 2 (POST-INTERVENTION TEST)

SECTION A

(1) a) Titrant is the solution whose concentration is known (i.e. the standard solution) in titration. **1 mark**

b) End point is the point in a titration process where equivalent amount of the solutions of the titrant and analyte have completely reacted, which is indicated by a colour change by the indicator used. **1 mark**

c) Equivalent point is the point in a titration process when amounts of each reactant as indicated in a balanced stoichiometric equation have reacted together. **1 mark**

d) Analyte is:

i) the solution whose concentration is to unknown

ii) the solution whose concentration is to be determined in titrimetry.

iii) the solution which is being analyzed in the titration process.

Any one correct score 1 × 1 = 1 mark

APPENDIX C CONTINUED

SECTION B

(1). ***The completed table***: **[1×12= 12marks]**

Type of Acid-base Titration	Best indicator	Indicator's pH- range	Examples of the reaction
Strong acid & Strong base	**Any indicator can be used.** **i)Phenolphthalein** **ii) Methyl orange** **iii) Litmus (Red/Blue)**	**1). 8.2 - 10.0** **2). 5.0 – 8.0** **3). 3.2 – 4.4**	**$HCl + NaOH \rightarrow$** **$H_2SO_4 + KOH \rightarrow$**
Strong acid & weak base	**Methyl orange**	**3.2 – 4.4**	**$HCl + NH_3 \rightarrow$**
Strong base & weak acid	**Phenolphthalein**	**8.2 – 10.0**	**$NaOH + CH_3COOH \rightarrow$**
Weak acid & weak base	**No suitable indicator**	**………………..**	**$CH_3COOH + NH_3 \rightarrow$**

SECTION C

1) **Some apparatus used for titration**

i) Pipette ii) Burette iii) Conical flask

iv) Beaker v) White tile vi) Filter paper

vii) Conical flask & clamp viii) White tile ix) Retort stand

x) Wash bottle xi) Pipette filter xii) Dropper

xiii) Wash bottle xiv) Reagent Bottle

Any correct four score (1×4) = 4 marks

APPENDIX C CONTINUED

2. Sources of errors in titration measurements

a) Inability to read volumes of pipette and burette correctly may be introduced into titration measurement.

b) Inability to determine colour change at the end point may lead to overshooting the end point.

c) If the funnel is left on the burette during titration, drops of solution from the tip of the funnel fall into the burette to increase the initial burette reading and decrease the end point

d) If the last drop of solution at the tip of the pipette is blown into the conical flask, it increases the measured volume of solution delivered and increase the end point of the titration.

e) If air bubbles in the pipette or the burette are not flushed out, it affects the volumes delivered. It increases the end point of the titration when bubbles disappear during the titration.

f) Viewing the meniscus from varying heights affects the volume readings.

g) Using dirty glassware will contaminate the solution.

Any correct three score (1×3) = 3 marks

(3) (i) 10.50, 10.50 and 10.40

Consistent titres :- 10.50 and 10.50

Average titre values:- $\frac{10.50+10.50}{2}$ = **10.50cm^3** **1 mark**

(ii) 27.50, 27.80 and 27.50

Consistent titres:- 27.50 and 27.50

Average titre value:- $\frac{27.50+27.50}{2}$ = **27.50cm^3** **1 mark**

APPENDIX C CONTINUED

SECTION D

(1). **Balanced chemical equations:-**

(a). $NaOH + HNO_3 \rightarrow NaNO_3 + H_2O$

(b). $2KOH + H_2SO_4 \rightarrow K_2SO_4 + H_2O$ **2 × 2 = 4 marks**

(2). Balanced chemical equations:-

(a). $H_2Y + 2KOH \rightarrow K_2Y + 2H_2O$

(b). $H_2SO_4 + X(OH)_2 \rightarrow XSO_4 + 2H_2O$

(c). $2HNO_3 + Na_2CO_3.xH_2O \rightarrow 2NaNO_3 + CO_2 + (x + 1) H_2O$

2×3 = 6 marks

SECTION E

1) a) Titration of HCl against Na_2CO_3 using methyl orange as indicator

Burette readings/ cm^3	1	2	3
Final burette readings/cm^3	27.50	27.20	27.20
Initial burette readings/cm^3	0.00	0.00	0.00
Volume of acid used/cm^3	27.50	27.20	27.20

Consistent titres:- 27.20 and 27.20

Average titre value:- $\frac{27.20+27.20}{2}$ = **27.20cm³** **Including the table = 6 marks**

b) ***Balanced Chemical Equation:***

$Na_2CO_{3(aq)} + 2HCl_{(aq)} \rightarrow 2NaCl_{(aq)} + CO_{2(g)} + H_2O_{(l)}$ **3 marks**

c) i) ***Concentration of the concentration of the acid in moldm^{-3}.***

Balanced chemical equation

$Na_2CO_{3(aq)} + 2HCl_{(aq)} \rightarrow 2NaCl_{(aq)} + CO_{2(g)} + H_2O_{(l)}$ $\frac{1}{2}$ ***marks***

APPENDIX C CONTINUED

From the equation above the mole ratio: $\frac{n(Na_2CO_3)}{n(HCl)} = \frac{1}{2}$ $\frac{1}{2}$ ***marks***

But n (HCl) = C × V = 0.100$moldm^{-3}$ × 0.0272dm^3 = 0.00272mol $\frac{1}{2}$ ***marks***

∴n(Na_2CO_3) = $\frac{1}{2}$ × 0.00272mol = 0.00136mol $\frac{1}{2}$ ***marks***

∴25cm3 of Na_2CO_3 solution contains 0.00136mol

∴1000cm^3 of Na_2CO_3 solution will contain $\frac{1000}{25}$×0.00136 = 0.0544mol

∴ C(Na_2CO_3) = **0.054$moldm^{-3}$** **1 mark**

ii) ***Concentration of Na_2CO_3 in gdm^{-3}***

ρ = C × M **1 mark**

But M(Na_2CO_3) = 2Na + C + 3(O)

= (2× 23) + 12 + (3×16) = 46 + 16 + 48 = 106$gmol^{-1}$ $\frac{1}{2}$ ***marks***

ρ(Na_2CO_3) = C× M = 0.0544 × 106 = **5.77gdm^{-3}** $1\frac{1}{2}$ ***marks***

APPENDIX D

INTERVIEW GUIDE FOR STUDENTS

Explain the physical criteria you would see to determine the completion of titration/titrimetry process.

Explain the effect indicators have on the titration/titrimetric process.

Describe major steps that should be followed to ensure effective titrimetric process.

APPENDIX E

QUESTIONNAIRE

INSTITUTION: Breman Asikuma Senior High School

Please this questionnaire is intended to seek for your views on the use of the STAD as a teaching strategy to improve the performance of students on titrimetric analysis. The responses from this questionnaire are for academic use only. Hence your responses will be kept completely confidential.

Class: ………… Age: …………… Sex: ………….

Kindly read through each question and tick (√) the appropriate option that matches your view.

STRONGLY AGREE = SA; AGREE = A; UNDECIDED = U; DISAGREE = D; STRONGLY DISAGREE = SD

1. The STAD motivated students in teaching and learning of the terminologies in titrimetric analysis. Strongly Agree ( ), Agree ( ), Undecided ( ), Disagree ( ), Strongly Disagree ( )
2. The STAD made lesson noisy.

Strongly Agree ( ), Agree ( ), Undecided ( ), Disagree ( ), Strongly Disagree ( )

3. The STAD made the lesson more interesting.

Strongly Agree ( ), Agree ( ), Undecided ( ), Disagree ( ), Strongly Disagree ( )

4. The STAD confused me to identify the commonest acid-base indicators often used in titration process.

Strongly Agree ( ), Agree ( ), Undecided ( ), Disagree ( ), Strongly Disagree ( )

5. The STAD made me learn easily from colleague classmates

Strongly Agree ( ), Agree ( ), Undecided ( ), Disagree ( ), Strongly Disagree ( )

APPENDIX E CONTINUED

6. The STAD as a teaching and learning strategy helped me participate actively in class for skills acquisition on titration / titrimetric / quantitative process.

Strongly Agree ( ), Agree ( ), Undecided ( ), Disagree ( ), Strongly Disagree ( )

7. It was difficult to work with colleague classmates in balancing chemical equations with the use of the STAD as a teaching and learning strategy

Strongly Agree ( ), Agree ( ), Undecided ( ), Disagree ( ), Strongly Disagree ( )

8. The STAD as teaching and learning strategy for titrimetric analysis was boring.

Strongly Agree ( ), Agree ( ), Undecided ( ), Disagree ( ), Strongly Disagree ( )

9. The STAD delays individual as well as group learning.

Strongly Agree ( ), Agree ( ), Undecided ( ), Disagree ( ), Strongly Disagree ( )

10. The STAD made solving of problems application of titration standardization of solutions in volumetric analysis self -explanatory.

Strongly Agree ( ), Agree ( ), Undecided ( ), Disagree ( ), Strongly Disagree ( )

11. The STAD made me inactive in titrimetric process in the lesson.

Strongly Agree ( ), Agree ( ), Undecided ( ), Disagree ( ), Strongly Disagree ( )

12. At anytime and anywhere the STAD can be used.

Strongly Agree ( ), Agree ( ), Undecided ( ), Disagree ( ), Strongly Disagree ( )

APPENDIX E CONTINUED

13. Briefly give a reason to your response to question 12 above.

………………………………………………………………………………………

………………………………………………………………………………………

14. The STAD as teaching strategy for titrimetric process was time consuming.

Strongly Agree ( ), Agree ( ), Undecided ( ), Disagree ( ), Strongly Disagree ( )

15. Briefly give a reason to your response to question 14 above.

………………………………………………………………………………………

………………………………………………………………………………………

16. Do you appreciate the use of the STAD in teaching and leaching of titrimetric analyses?

YES ( ) UNCERTAIN ( ) NO ( )

Give brief reason…………………………………………………………………………………

17. Do you want the STAD to be used always in the class?

YES ( ) UNCERTAIN ( ) NO ( )

Give brief reason………………………………………………………………......

APPENDIX F

RAW SCORES FOR PRE AND POST – INTERVENTION TEST

(TOTAL MARK = 100)

SN	Pre-intervention score	Post-intervention score	SN	Pre-intervention score	Post-intervention score	SN	Pre-intervention score	Post-intervention score
1	64	88	**33**	28	74	**65**	70	84
2	20	32	**34**	13	36	**66**	28	45
3	05	13	**35**	03	05	**67**	28	79
4	21	61	**36**	06	50	**68**	40	78
5	18	90	**37**	42	63	**69**	24	74
6	25	55	**38**	30	48	**70**	22	68
7	38	64	**39**	35	78	**71**	44	60
8	24	65	**40**	38	85	**72**	38	65
9	50	85	**41**	73	86	**73**	24	40
10	12	60	**42**	08	75	**74**	23	36
11	45	87	**43**	04	25	**75**	58	75
12	48	80	**44**	27	60	**76**	07	17
13	28	53	**45**	20	63	**77**	15	70
14	61	90	**46**	55	72	**78**	50	76
15	25	78	**47**	28	79	**79**	68	61
16	40	89	**48**	65	90	**80**	42	41
17	28	72	**49**	53	65	**81**	15	30
18	51	73	**50**	25	52	**82**	72	84
19	31	68	**51**	42	54	**83**	08	65
20	53	75	**52**	12	30	**84**	19	96
21	06	21	**53**	25	63	**85**	14	65
22	75	92	**54**	10	61	**86**	24	59
23	19	70	**55**	05	10	**87**	12	63
24	40	77	**56**	12	66	**88**	48	80
25	21	86	**57**	20	62	**89**	21	40
26	31	76	**58**	40	74	**90**	25	55
27	04	08	**59**	24	25	**91**	08	65
28	20	48	**60**	18	92	**92**	34	82
29	32	50	**61**	11	20	**93**	21	75
30	18	85	**62**	23	66	**94**	20	54
31	32	72	**63**	62	85	**95**	30	78
32	26	48	**64**	26	60			

APPENDIX G

RAW SCORES FOR PRE AND POST – INTERVENTION TEST FOR BOTH MALES AND FEMALES

(Total mark = 10)

SN	MALE		FEMALE		SN	MALE		FEMALE	
	Pre-intervention score	Post-intervention score	Pre-intervention score	Post-intervention score		Pre-intervention score	Post-intervention score	Pre-intervention score	Post-intervention score
1	64	88	21	61	**29**	55	73	22	68
2	20	32	24	65	**30**	53	65	58	75
3	05	13	50	85	**31**	25	55	15	70
4	24	25	48	80	**32**	42	54	08	65
5	25	55	61	90	**33**	12	30	19	96
6	38	64	28	72	**34**	25	63	14	65
7	12	60	53	75	**35**	40	74	12	63
8	45	87	19	70	**36**	18	92	48	80
9	28	53	31	86	**37**	23	60	21	40
10	25	78	31	76	**38**	26	60	08	65
11	40	89	04	08	**39**	70	80	34	82
12	51	73	28	74	**40**	28	45	21	75
13	31	68	06	50	**41**	40	78		
14	06	21	38	85	**42**	44	60		
15	75	92	08	75	**43**	38	65		
16	40	77	04	25	**44**	24	40		
17	20	48	20	63	**45**	23	36		
18	32	50	28	79	**46**	07	17		
19	10	61	65	90	**47**	50	76		
20	26	48	18	85	**48**	68	61		
21	32	72	05	10	**49**	42	41		
22	13	36	12	66	**50**	15	30		
23	03	05	20	62	**51**	72	84		
24	42	63	18	90	**52**	30	78		
25	30	48	11	20	**53**	24	59		
26	35	78	62	85	**54**	25	55		
27	73	86	28	79	**55**	20	54		
28	27	60	24	74					