UNIVERSITY OF EDUCATION, WINNEBA

USING MODEL TO TEACH DOUBLE INDICATOR TITRATION BASED ON THE CONSTRUCTIVIST APPROACH

DESMOND ADARKWAH

2016

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(7140130004)

A DISSERTATION IN THE DEPARTMENT OF SCIENCE EDUCATION, FACULTY OF SCIENCE, SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, UNIVERSITY OF EDUCATION, WINNEBA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A MASTER DEGREE IN SCIENCE EDUCATION (M.Ed. SCIENCE)

OCTOBER, 2016

DECLARATION

CANDIDATES DECLARATION

I, Desmond Adarkwah declare that, the work in this dissertation entitled “a practical teaching model for double indicator titration based on constructivism” has been carried out by me in the department of science education. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at this or any other institution.

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

SUPERVISOR’S DECLARATION

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

Supervisor: DR. E. K. OPPONG

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

DEDICATION

This dissertation is dedicated to my father, Mr. E.K.A. Ashia for his advice, guidance and financial support in my entire life. I most probably would not have come this far.

ACKNOWLEDGEMENT

First and foremost, I would like to express my profound gratitude and thanks to Almighty God, the Creator, and Sustainers' of the universe, the Gracious, the Merciful, the Mighty through whose mercies has made it possible for me to undertake this study.

I would like to thank my supervisor, Dr. E.K Oppong, for his encouragement, discussions and suggestions have made this piece of work a possibility. I am extremely grateful to have had you as my supervisor.

I would also like to thank Prof. John K. Emina for taking the time to be the second reader of my project; your expertise on technology use in education has contributed greatly to the finished product. Also, many thanks to Dr. J.A Annan, Dr. Azure, Dr. Anderson and Prof. Taale who guided me down the right path and helped me through the difficult times; I am blessed to know all of you.

I would also like to thank Mr. Gilbert Blessing who always supported me with his technical support, which is something I will always appreciate; thank you for the assistance.

I am highly indebted to Mr. Ibrahim Mohammed of Oda Senior High School.

I am also grateful to the authorities of Kade Senior High School, St. Roses Senior High School, Akwatia Technical Institute and Salvation Army senior high School- Akim Wenchi for allowing me to undertake my research work in their schools.

Lastly, very special thanks to my course mates for always being there to encourage me through the good and bad times so this project could become a reality; I love you.

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ABSTRACT

The purpose of this study was to use model to teach double indicator titration at the SHS. Five research questions were formed to guide this study. This study used action research design using quantitative approach. Purposive and simple random sampling procedures were employed to select one hundred and seventy-five (175) participants for the study. Classroom observational checklist and questionnaire were the instruments used to collect data in the study. Descriptive statistics tools (frequency, percentage, mean and standard deviation) were used to analyze the quantitative data. Findings of the study revealed that, chemistry teachers do not use practical activities in double indicator titration and this had adverse effects on their academic performance. Also, developed model (DEPTEM) was seen as an effective practical model in teaching double indicator titration at the SHS as compared to the teachers' method. Furthermore, the DEPTEM influenced SHS chemistry students' academic performance positively. Finally, there was a difference between male and female students' academic achievement of the concept double indicator titration after been exposed to the DEPTEM. Based on these findings it was concluded that, chemistry teachers in the Kwaebibirim District of the Eastern Region used lecture method in teaching double indicator titration instead of practical activities and this had negative effects on their academic performance. It was then recommended that in-service training should be organized for chemistry teachers and newly recruited chemistry teachers to use more of the developed practical model (DEPTEM) in relation to the lecture method.

CHAPTER ONE

INTRODUCTION

1.0 Overview

The chapter contained information on the background to the study, statement of the problem, the purpose of the study, research objectives and questions. It further spelt out the significance of the study, limitations, delimitation, operational definition of terms and organization of the study.

1.1 Background to the study

In all the history of education, science has held its leading position among all school subjects because it is considered as an indispensable tool in the development of the educated person. It is the bedrock of scientific and technological careers and development (Uche, S.C. and Umoren,G.U, 1998). Educators give special recognition to chemistry among the sciences because of its educational values, close relation to man as living organism, peculiar field of experimentation and interrelationships with the other sciences (Akinmade, 1987). The primary aim of science is to collect data. An ultimate purpose of science is to discern the order that exist between the various data (Sheldon, 2011). As a result of this chemistry occupies a relatively pivotal position in the science and it is one of the requirements to professions such as pharmacy, medicine, agriculture and many others.

The importance accorded science, and for that matter chemistry, in the school curriculum from the basic to the senior high level reflects accurately the vital role played by the subject in contemporary society. The importance of the subject is not restricted to the development of individual alone but for the advancement of the social, economic, industrial and political goals of countries all over the world. In Ghana chemistry as a subject is known to have a significant number of student enrolments in recent years in senior high schools. By having knowledge in science education, the economy and socio-cultural status will be transformed (Anamuah-Mensah, 1989). This implies that science education and for that matter chemistry is important in producing the required human resources needed for harnessing the natural resources of the country.

The current approach to science teaching and learning in most senior high is most often based on classroom and laboratory works which are intended to meet examination requirements (Chris Dede, Diane Jass Ketelhut and Pamela Whitehouse, 2009). Unfortunately the examination driven mode of chemistry teaching and learning has limited the chemistry technological scope and perspectives of the students. The approach also tends to make the study of chemistry uninteresting and boring. Students find it difficult to relate the theoretical knowledge with the practical realities of life and the use of manipulative skills. There is also very little orientation for problem solving, inculcation of investigative skills and counseling on chemistry career opportunities. It is therefore necessary that students studying chemistry should understand the subject so that they can apply their knowledge to everyday interactions with people and their ever changing environment.

According to Nwosu (2003), the teacher is an important determinant of the quality of learning by the learner. The teachers are the pivot of the education system and therefore they are at the center of any reform effort in the system (Eze, C.C. and Njoku, Z.C., 2011). It is the teacher who organizes the interactions between the learner and the learning materials (Ikeobi.I, 2004). All these points to the fact that, the teacher is very significant factor when the learners fail to exhibit the expected mastery in a science subject such as chemistry practical.

The chemistry teacher should adopt methods that would enable the student to understand whatever concepts or principles that are being taught. There are various ways of teaching chemistry such as projects, field trips, expositions, experimental and guided discovery strategies. All these methods rely on various forms of teacher- student activities; however some are more activity oriented than others. The guided discovery has been recommended for teaching the contents of senior high school (SHS) Chemistry Curriculum in Nigria (FGN-NPE, 2007). This approach is activity oriented for both teacher and student. It applies abundantly the principle of effective questioning, appropriate directives, demonstration by the teacher, high quantity and quality students' activities (laboratory work, field trips, class discussions).

In all these, the students accumulate the products of science by vigorously engaging in various processes of science (Demide, 2000). According to Kolb (1984), knowledge is constantly extracted from a learning individual's experience and tested. Thus in the guided discovery, the students are active participants in the teaching and learning situation and so they actually do chemistry and not just being taught t chemistry. In view of this and also to make the strategy effective, the Ghana government through the ministry of education in 1997, set up 110 Science Resource Centers (SRC) in all the

Districts in Ghana. The SRC have laboratory facilities with modern equipment (Agyimfrah, 2015). The SRC serves as teaching Centre and promotes practical work. The SRC has laboratory assistant, a coordinator and a budget to renew and buy the needed materials. Manuals as well as computers for practical work are available. The SRC also organizes workshop for teachers (Agyimfrah, 2015).

Despite these improvement in the training of the science teacher and his teaching capabilities, students' performance in chemistry practical continue to be low according to the West African examination council chief examiners report for senior high school certificate examination (2002-2007). The descending performance of chemistry students is due to the wrong way and manner teachers teach practical chemistry (Njoku, 2007). Oleyede, (2004) posits that one of the reasons for the poor performance of students in Chemistry is the methods used by the teachers. From the above discussion, it is clear that there is the need to improve on the methods of teaching chemistry practical to student. For this reason this research seeks to design practical teaching model based on constructivist approach in teaching the topic "double indicator titration involving HCl against Na_2CO_3/NaOH mixture".

1.2 Statement of the Problem

Chief Examiners' Reports on SHS chemistry paper 3 (2007) shows that most students have continued to perform poorly countrywide in comparison to paper 1 and 2. The Chief Examiners' Reports further pointed out that, it is clear from candidates' answers that only few schools follow a practical approach to the teaching of chemistry (WAEC, Ghana, 2007). It has also been observed (by the researcher) that most practical activities in science (chemistry) education in most SHS in Kwaebibirim District of the Eastern Region is still a pipeline dream as few teachers are capable of teaching chemistry practical work; and many chemistry teachers still need assistance on how to involve students in meaningful practical activities.

Again, informal observations by the researcher for the past eight years on some chemistry teachers in Kwaebibirim District of the Eastern Region indicated that, most of the teaching skills acquired before certification are not put into practice. The deficiencies in chemistry teaching range from; non-coverage of contents in schemes of work, non-giving and marking of assignments, non-supervision of instruction, non-organization of practical lessons, non-organization of extra lessons to cover lost lessons, non-assessment of learning outcome on regular bases, non-application of improvisation knowledge in instruction to non-taking of students to field experiences. All these tend to suggest that, sometimes teachers are to be blamed for lack of proper exposure of chemistry students which result in poor performance of students in High School chemistry. It is against this background that this study was conducted.

1.3 Purpose of the Study

The purpose of this study was to use model to teach double indicator titration at the SHS level.

1.4 Research Objectives

The objectives of this study were to:

1. Identify teaching and learning strategies used by chemistry teachers when teaching double indicator titration at the SHS.

2. Develop a chemistry practical teaching model for double indicator titration for senior high school level.

3. Identify the effectiveness of the developed practical model in teaching double indicator titration at the SHS.

4. Determine ways through which the use of the developed model influences students' academic performance in double indicator titration?

5. Determine whether there is a difference between male and female students' academic achievement of the concept double indicator titration after being exposed to the practical teaching model.

1.5 Research Questions

The following research questions were formulated to guide the study:

1. Which teaching and learning strategies are used by chemistry teachers when teaching double indicator titration at the SHS?

2. In what other ways can the teaching and learning of double indicator titration be done?

3. How effective is the practical teaching model in teaching double indicator titration at the SHS?

4. In what ways does the use of the practical teaching model influences students' academic performance at SHS?

5. Is there any difference between male and female students' academic achievement of concepts in practical chemistry after being exposed to the practical teaching model?

1.6 Significance of the Study

The importance of the research cannot be overlooked. It was expected that, findings from this study would provide science educators, science curriculum planners and government with detailed picture of science (chemistry) teaching and learning, and educational practices in SHS in Ghana and realistic cost effective ways of improving the situation. This in turn would help in planning and formulating further policies for chemistry education in Ghana.

Additionally, findings from this study would throw light on the methods used by chemistry teachers in chemistry teaching and learning at the SHS level and to determine whether their methods are effective in improving the performance of students. Likewise, the study would create the awareness to school authorities, chemistry teachers and students in Kwaebibirim District of the Eastern Region about the factors that hinder their academic performance in chemistry education.

More so, the findings would add to existing knowledge on solutions to learners' problems of not performing well in the practical examination paper. Similarly, chemistry teachers would benefit from this study by ascertaining whether or not their practical activities are adequate to improve upon the academic performance of chemistry students. Likewise, findings and recommendations of the study would help chemistry teachers re-examine their teaching methods and lesson delivery in the quest to maximize students' learning outcomes.

Again, the findings would help in designing the science curriculum for teacher training courses in order to teach chemistry effectively at the SHS level, chemistry teachers must first experience practical-activity teaching methods while in training, so that they can also impact such knowledge and skills when they come to the field of work.

Notwithstanding the above, findings from this study would be used by other researchers as a baseline study for future studies in the area. Lastly, the findings of the study can provide insight in designing chemistry materials to be used in SHS in Ghana and beyond.

1.7 Limitations

Due to shortage and cost of laboratory equipment and reagents, the number of times practical work in the laboratory were to be conducted with the experimental group was reduced from fifteen to ten during the period of the study.

Secondly, the study should have been conducted in other Senior High Schools in Ghana offering science programme. However, the study was narrowed down in scope due to financial constraints and the time frame. The study was limited to only two Senior High Schools in Kwaebibirim district in the eastern region of Ghana.

1.8 Delimitations

Though there were numerous topics in the chemistry syllabus for Senior High Schools, practical aspect of chemistry was chosen for this study because of the mass failure of students in the practical chemistry examination (WAEC, Chief Examiners' report, 2007). The aspect of the practical involved in the study was acid-base titrations where the failure rates of students had been observed (Njoku, 2007).

. Due to financial constraints, the study would cover 150 students and 25 teachers. The research is confined to SHS Two and Three students. Students in senior high school one were excluded due to the fact that at the time of the study they had not engaged in the theory of acid, base and practical hands-on experience in acid – base titrations involving the use of one indicator.

1.9 Operational definition of terms

WAEC	West African Examinations Council, the examination body which conduct examinations for basic and second cycle schools in some English Speaking West African countries including Ghana.
SSSCE	Senior Secondary School Certificate Examination.
WASSCE	West African Secondary School Certificate Examination.

DEPTEM	is an acronym for "developed practical teaching model".
Control Group	it refers to the students who were exposed to the traditional method of teaching.
Experimental group	It refers to the students who were taught double indicator titration using DEPTEM based method of teaching.
Pre-test	A test given to students in order to know their knowledge level before exposing them to the teaching method.
Post-test	A test given to students to know their knowledge level after exposure to a teaching method.
Observation Check list	is a list of questions that an observer would be looking to answer when they are doing a specific observation in the classroom.

1.10 Organization of the Study

This research report was presented in five chapters. The first chapter dealt with the background to the study, statement of the problem, the purpose of the study, research objectives and questions. It further spelt out the significance of the study, delimitation, limitations, operational definition of terms and organization of the study.

The chapter two reviewed relevant literature on the study while chapter three dealt with the methodology. This comprised of the research design, population, sample and sampling techniques, and instrumentation. It also discussed the reliability and validity of the instruments, data collection procedure, method of data analyses. Chapter four dealt with the presentation of results and the discussion of the findings. Lastly, the summary, conclusions to the main findings and recommendations constituted the fifth chapter.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter includes the literature that has been reviewed under the following heading: aims of practical chemistry, factors influencing effective teaching of chemistry; methods of teaching practical chemistry, double indicator titration, constructivist theory and the developed practical teaching model, constructivist science classroom, inquiry-base science learning and overview of similar studies.

2.1 Aims of practical chemistry

Chemistry is a practical oriented subject that occupies a prominent place in SHS science curriculum (Ugwu, 2007). It is an experimental science that needs a high level of practical work for its understanding, development and application. Practical work enables students to understand scientific concepts in everyday life. It also assists them to apply the learned chemistry concepts and skills to social problems and understanding scientific and technological principles involved in household devices (Morrell, 1972).

The original reasons for laboratory development lay in the need to produce skilled technicians for industry and highly competent workers for research laboratories. There are many espoused purposes for doing practical work (Lunetta, 2007). The quality of practical work varies considerably but there is strong evidence from this country and elsewhere that; when well-planned and effectively implemented, science education laboratory situate students' learning in varying levels of inquiry; requiring students to be both mentally and physically engaged in ways that are not possible in science education experiences.

Eya, (2015) conducted an investigation in the contents of the senior high chemistry curriculum that can inculcate entrepreneurial skills and concluded that there are many of such concepts in the SHS curriculum with quantitative analysis; Acid – base titrations recording the second highest mean and standard deviation of 3.81 and 0.29 respectively. Real world applications of titration are in the field of developing new pharmaceuticals and determining unknown concentrations of analyte of interest in blood and urine. Practical activities are designed to make the students active participants; such methods are in their infancy in chemical education (Alexander, 2001). (Carnduff, 2003), some of the objectives of practical work are to:

- encourage accurate observation and description
- promote a logical reasoning and formulate hypothesis
- use knowledge and skills acquired in unfamiliar situations
- develop interpretation skills
- develop problem solving skills
- design simple experiments and to test hypothesis

2.2 Factors influencing effective teaching of chemistry

Much effort has been made to identify the problems that are inherent in the teaching of chemistry in SHS. These factors influence the effective teaching of chemistry which in turn plays a vital role in the lives of the students as it affect their performance. These include physical class room and laboratory, In-service training, School management, Instructional arrangement or methodology and etc. (Johnson, 2011).

The physical classroom needs good ventilation, availability of good chalk board, enough chairs and tables, charts and clean environment. (Yara, 2011), other factors of the physical classroom include the presence of instructional materials in the laboratory such as apparatus and chemicals. The school management is another vital factor that may be considered before anticipating a good result. Some of the responsibilities of the school management include provision of library, laboratory, and essential services such as light, food vendors, counselor and first aid (Yara, 2011).

2.2.1 Effective chemistry laboratory

The science laboratory is a setting in which students can work supportively in small groups to investigate scientific occurrences (Aina, 2012). Laboratory activities have had a distinctive and central role in the chemistry curriculum and chemistry educators have suggested that many benefits accrue from engaging students in laboratory activities (Hofstein A. Lunetta, 2004). It is in this view that the Ministry of education in 1997 established Science Resource Centres in 110 districts in Ghana. There are still inadequate laboratories due to the growing number of SHS which outnumber the SRCs' available (Sam, 2009).

Infrastructure is often stressed as a result of the insufficient or incomplete laboratory equipment in most of the public primary and senior high schools both in the urban and rural areas. Since chemistry is an experimental branch of science, laboratory is the only place that is capable of developing students' scientific processing skills (Adefunke, 2008). Owoeye and Yara, (2011) observed that an important ingredient for effective science teaching is an appropriate items; laboratory equipment and materials. According to Rai (1985), a standard laboratory should make provisions for the following:

1. Staff offices for lab technicians
2. Fume chamber for preparation of poisonous gas
3. Central storage room; where dangerous chemicals are kept
4. Resource room where students carry out their project work

A standard laboratory should also have the necessary glassware and apparatus needed for practical as well as protective wares. Having all the above, effective laboratory should be operational.

2.2.2 In – service training for chemistry teachers

Teacher can be referred to as a catalyst that brings about changes in the behaviour of the student; the teacher plays a central role in the actualization of educational systems (Okecha, 2008). In - service training is a programme that intends to provide update, improvement conversions and support to teaching professionals along their careers. The training actions can be drawn by schools according to the needs of their teachers or it may result from the individual initiative of the teacher (Pereira, 2013). A continuous teacher training is the keystone of improvement and transformation in schools for personal growth and development (Abuseji, 2007).

The importance of in-service training and professional development of teacher has been given serious thought and effort. With regards to this the Ministry of Education through the Science and Mathematics Education Unit in conjunction with ITEC global organizes workshops yearly for science teachers in Ghana (Agyimfrah, 2015). In the workshops, Teachers from different schools are accommodated at one place and giving four weeks intensive training. The training is based on

- Inculcating effective laboratory activities to classroom activities to enhance learners understanding of scientific concepts.
- Various forms of improvisation for teaching and learning resources in certain concepts
- How to make certain abstract concepts more concrete to the learner.

Okoro, (2011) conducted a study on teacher education, school effectiveness and improvement; and stressed that teachers required professional knowledge and teaching skills to carry out instructional process effectively. He also suggests that teachers should be both academically and professional trained. However, the training venues should be a place of convenience and have all necessary equipment and infrastructure. Barnea, (2007) viewed that training for the teachers should be conducted in a comfortable and relaxed environment that is conducive to change. This is why in Ghana venues such as Opoku ware and Prempeh SHS are used for training of science teachers since these schools have well equipped laboratories and organized environment. It also implies that teachers are more important than the quality and quantity of equipment and material and the extent of financing. FGN-NPE, (2007) recognized the importance of teachers in an educational system and emphasized that, no educational system can rise above the quality of its teachers and promised that, the government will continue to give major emphasis to teacher education in all the country's educational planning activities.

2.2.3 Methods of teaching practical chemistry

There is increasing concern among practitioners and educational researchers about the effectiveness of teaching. Byrne, (1983) suggested that, it is surely plausible to suggest that in so far as a teachers knowledge provides the basis for his/her effectiveness, the most relevant knowledge will be that which concerns the particular topic being taught and the relevant pedagogical skills. To teach successfully, one must know how to facilitate a positive learning experience of students. One of the limitations of learning is the method of instruction which falls short of learners' needs. There are many methods of instruction to practical chemistry but all the methods could be categorized into two. Namely student centered and teacher centered. According to Adepitan, (2003) and Okoronka, (2004), science subjects are not being taught to students' maximum benefit, because science instructions are mostly teacher centered.

In teacher-centered education, students put all of their focus on the teacher. The teacher talks, while the students exclusively listen. During activities, students work alone, and collaboration is discouraged. When a classroom operates with student-centered instruction, students and instructors share the focus. Instead of listening to the teacher exclusively, students and teachers interact equally. Group work is encouraged, and students learn to collaborate and communicate with one another. In recent years, more teachers have moved toward a student-centered approach. However, some maintain that teacher-centered education is the more effective strategy. In most cases, it is best for teachers to use a combination of approaches to ensure that all student needs are met. When both approaches are used, students can enjoy the positives of both types of education. Instead of getting bored with teacher-centered education or losing sight of their goals in a completely student-centered classroom, pupils can benefit from a well-balanced educational atmosphere.

2.3 Double indicator titration involving HCl against Na_2CO_3/NaOH mixture

This is a titration involving the use of two indicators, because the solution pipetted could be alkaline at one stage and at another stage in the titration the product formed could be acidic and vice versa. The common indicators used in the senior high school for this type of titration are phenolphthalein and methyl orange. The two indicators are considered in the determination of the volume of the acid used. Thus two titration tables are required in double indicator titration unlike other titration which requires single indicator. The titration is either continuous or discontinuous.

Double indicator titration is used to determine the purity of samples, estimate quantities of substances and to determine medicinal properties of substances.

There are several applications of double indicator titration but this study focuses on the one involving Na_2CO_3/NaOH mixture against HCl. The reactions taking place in this titration are:

i. $HCl + NaOH \longrightarrow NaCl + H_2O$

ii. $HCl + Na_2CO_3 \longrightarrow NaHCO_3 + NaCl + H_2O$

iii. $HCl + Na_2CO_3 \longrightarrow NaCl + CO_2 + H_2O$

iv. $HCl + NaHCO_3 \longrightarrow NaCl + CO_2 + H_2O$

2.3.1 How the concept "double indicator titration" is presented to students

The learner of double indicator titration is taken as an empty vessel in which knowledge is to be poured. Thus the learner only listens to and copy notes from the teacher.

2.3.2 Continuous method

In this method, the first endpoint is indicated by the change in color of phenolphthalein indicator from pink to colorless while methyl orange is used to estimate the second end point and the color changes from yellow to orange.

The letter Xcm^3 is used to denote the volume of HCl at phenolphthalein end point and Ycm^3 for volume of HCl used at methyl orange end point. A series of algorithmic expression is followed to arrive at a final expression:

- Volume of HCl that neutralizes all Na_2CO_3 = $2Y\ cm^3$
- Volume of HCl that neutralizes all NaOH = $(X - Y)\ cm^3$

2.3.3 Discontinuous method

In this method separate titration of the Na_2CO_3/NaOH mixture against the HCl is done using the indicators separately. With the same representations of the letters X and Y having their meanings as in the continuous method, the volume of HCl used is derived as;

- Volume of HCl that neutralizes all Na_2CO_3 = $2\,(Y - X)\ cm^3$

- Volume of HCl that neutralizes all NaOH = (2X – Y) cm^3

However, learners are supposed to keep these formulas in mind without understanding the main concept. It is important to note that ability to solve numerical problems does not mean an understanding of underlying concepts (victor, 2013). The demand of overloaded syllabus and time constraints in senior high schools (SHS) in Ghana, compel teachers to employ mostly the lecture method of teaching where students are giving many rules to learn in order to solve numerical problems (Kusi, 2013).

Indeed, some science teachers fail to realize that the nature of science subject is shifting and there is the need for a shift from old methods to routine practical learning. Despite the above methods, students still perform poorly in practical chemistry according to chief exam report (WAEC, 2002 – 2009). The practical chemistry covers 25% of SHS WASCE. The concept of acid base titration is prominent both conceptually and in the requirement for practical skills.

This study focuses on double indicator titration aspect of the acid – base titration. Students are required to determine the volume of acids/base used in the titration. These volume if determine would be used in subsequent estimation of quantities of substances.

Though teachers teach this area well yet students find difficulty in the determination of exact volumes of acids since two indicators are used. Therefore there is the need to come out with a model which incorporates student centered, teacher entered, inquiry and guided discovery using the constructivist approach. This is the Developed practical teaching method (DEPTEM).

2.4 Constructivist theory and the DEPTEM

The (DEPTEM) was developed based on learning that is derived from Constructivist Theory. The core concept of constructivism is that an individual learner actively constructs knowledge and meaning from his/her own experience through an adaptive learning process that integrates new knowledge into his/her existing cognitive structures (Cakir, 2008). The growth of constructivism is an epistemological commitment and instructional model that includes aspects of Piagetian, Ausubelian and Vygotskian learning theories; namely, the importance of ascertaining prior knowledge, or existing cognitive frameworks, as well as the use of dissonant events (relevant information) to drive conceptual change (Cakir, 2008). Constructivism in learning "is not a unified perspective but rather is expressed in different forms" or models (schunk, 1996). The developed practical teaching model is designed such that it builds on students' prior knowledge of titrations of HCl against NaOH and HCl against Na_2CO_3 involving single indicators (phenolphthalein and methyl orange). When this has been done, titration involving the mixture (NaOH/ Na_2CO_3) can be performed. One crucial difference among these forms is about the extent to which the model focuses on learners as independent individuals (psychological) in comparison to the social interactions between an individual and his social environment (Sullivan, 1998). The DEPTEM enables students work in groups thereby providing medium for discussion amongst students. For example, by interacting with others during group discussion or peer collaboration, students share their views, learn from each other, and generate an understanding related to the concept studied (kalpana, 2014). Another exceptionally important assumption in (Vygotsky, 1978) constructivist theory is the zone of proximal development (ZPD), defined by his words as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers". A cognitive change occurs in the ZPD as learners bring their own understandings to social interactions with teachers or more experienced people in the context. This conceptual change leads to learning new knowledge and constructing meanings when it is internalized in the learner (Schunk, 1996).

2.5 A Constructivist science classroom

The essence of constructivism is that knowledge is not transmitted among persons but rather is built up "either individually based on what student brings through prior experience or collaboratively by what participants contribute" (Kalpana, 2014). Introducing a cognitive conflict dis-equilibrates the new knowledge which in turn produces conceptual change or learning; thus, to promote meaningful learning from a constructivist perspective, it is crucial to stimulate cognitive conflict by employing a student-centered environment that allows interaction of students' beliefs with classroom instructional practices. In a constructivist science classroom, teachers do not stand in front of a group of students lecturing in a traditional way but rather they actively engage students in purposeful, hands-on activities that challenge students' existing conceptions leading them to reconstruct their understanding and personal theories (Cakir, 2008).

2.6 Inquiry-Based Science Learning

Scientific inquiry has been a standard in most policy reform documents during the last two decades (National Research Council, 2005). The National Science Education Standards define scientific inquiry as: “Multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating results” (National Research Council, 2005). Also, the National Research Council, (2005) has expanded their description of scientific inquiry activities to include laboratory experiences: “Laboratory experiences provide opportunities for students to interact directly with the material world (or with data drawn from the material world), using the tools, data collection techniques, models, and theories of science”.

Inquiry has been used in science education in a number of ways, ranging from the simple description of knowledge gain through applying the scientific method in well-designed activities to the complex instructional approach where teachers act only as facilitators and students actively guide their own learning process (Minner,D.D., Levy,A.J., & Century,J., 2010). Research has shown mounting evidence of the positive effects of integrating inquiry into science teaching and learning (Furtak, E.M., Seidel, T., Iverson, H., & Briggs, D.C., 2012). In their meta-analysis of inquiry-based science teaching, Furtak et al, (2012) compared and contrasted scientific inquiry in 37 studies published between 1996 and 2006 in terms of two dimensions: the cognitive dimension of inquiry and the guidance dimension of inquiry. The cognitive dimension consisted of four domains: conceptual structures and cognitive processes that were used during scientific reasoning; epistemic frameworks used when scientific knowledge was developed and evaluated; social interactions that shaped how knowledge was communicated, represented, argued, and debated; and procedural domain that described the methods of asking scientifically oriented questions, designing experiments, executing procedures, and analyzing data. The guidance dimension of inquiry identified the extent to which activities were guided by the teacher or student. The results of this meta-analysis indicated that engaging students in guided inquiry activities, specifically epistemic activities or the combination of procedural, epistemic, and social activities, has positive learning gains compared to traditional learning or unstructured student-led activities. The implementation of inquiry-based science teaching programme is posited to help motivate and engage students in science learning (Minner et al., 2010), improve their academic readiness and achievement (Areepattamannil, 2012) and reduce their resistance behaviours toward science and technology (Sever,D., & Guven,M., 2014).

Scientific investigations and hands-on activities play a distinctive role in inquiry-based science teaching and learning. During investigations and hands-on activities, students are required to use the scientific inquiry elements of questioning; stating a hypothesis; making a plan; conducting observations and experiments to generate artifacts; collecting information; drawing conclusions; and, communicating throughout the inquiry process (Wang,L., Zhang,R.,Clarke,D. & Wang,W., 2014). The intended outcome of the scientific investigations and hands-on activities in this curriculum unit was that students develop a deeper understanding of scientific concepts, enhance their research and problem solving skills, develop positive attitudes toward science, and improve their academic achievement in science subjects (Areepattamannil, 2012; Wang et al., 2014).

A research (Eya, 2015) was conducted into the approaches that can be used to teach chemistry at senior high. The findings indicated that inquiry and guided discovery are the best approach with a mean of 3.33 and 3.70 respectively. Harry, (2011) posits that even though laboratory activities breed interest in students' attitude to science education, it does not warrant realization of the goal of science teaching and learning, rather the combination of all the teaching and learning methods should be used due to the variation in the students.

Students need to be encouraged to become deeply involved in the laboratory work so as to develop their skills. Lagowski, (1990) conducted a study on student knowledge retention and it showed that, students retain 10% of what they read; 26% of what they hear; 30% of what they see; 50% of what they see and hear; 70% of what they say and 90% of something they say while performing a task. The researcher would want to find out whether the DEPTEM can be a tool for teachers and also enhance students understanding in determining clearly the volumes of acids/base used in double indicator titration.

2.7 Overview of similar studies

Due to the importance of practical activities and concept learning in science education, a great deal of researches in science education have been carried out in this aspect and the following are summaries of some of such research work. A case study (Wagner, 2006) analysis suggests that students' conceptual understanding depends on the context, in which the concepts are being taught and therefore requires acquisition of concepts representation. Also, a study (Neslihan, 2009) was conducted to determine whether the development of chemistry concepts has similarities with the students' conceptual understanding. The study was carried out with a cross-sectional research in the form of a case study and the results revealed that with proper concepts teaching, students understood the concepts in chemistry better. Reform efforts that introduce conceptual instruction in mathematics have been extensively studied with mixed results.

A research (Jodi, 2010) was also conducted on the development of conceptual instruction and problem solving expertise in chemistry to find out whether there is evidence that conceptual instruction on the meaning behind calculations can be attributed to difference in problem solving and the result was that problem solving performance relates to conceptual understanding of the quantities involved in calculation. In a research (Douglas, 1997) on the effect of explicit problem-solving instruction on high school students' problem-solving performance and conceptual instruction in physics, eight physics classes with a total of 145 students were randomly assigned to either a treatment or comparison group. The four treatment classes were taught how to use an explicit problem solving strategy, while the four comparison classes were taught how to use a textbook problem solving-solving strategy. Students' problem-solving performance and conceptual instruction were assessed both before and after instruction. The result indicated that explicit strategy improved the quality and competence of students' physics representations more than the textbook strategy, but there was no difference between the two strategies on match of equations with representations, organizations with representations, organizations or mathematical execution. In terms of conceptual understanding, there was no overall difference between the two groups.

In a conceptual research conducted (Magada, 1996) on the comparative study of impact of conceptual and systems approaches on the effective learning of geography, he found out that there was a significant difference in the effective learning between learners taught using the conceptual approach alone and those taught using a combination of the conceptual and systems approach. It was established that a combination of conceptual and systems approach was more effective than the conceptual approach alone. An investigation (Go'khan, D. Alipasa, A.and Hulya, D., 2005) into the effects of students achievement of new teaching material developed for the unit “acids and bases”. Also, the students’ attitudes towards chemistry were explored. The new materials included work sheets base on conceptual instructional method, the sample consisted of thirty eight students. The findings from the posttest indicated that the students in the experimental group taught with the new teaching material showed significantly greater achievement in the unit acids and bases than the students in the control group. In addition, the experimental group had a significantly higher score than the control group, with regard to their attitudes towards chemistry. This shows that the implementation of the new material produced better results both in terms of achievement and attitudes.

In another study (Boujaoude, 2003) investigated the relationship between students’ problem-solving strategies in stoichiometry and their conceptual performance and to their learning approaches (e.g. deep approach versus relating ideas versus intrinsic motivation among others). Based on the findings that indicated a connection between sound conceptual and procedural knowledge and successful problem solving, they administered a learning approach questionnaire (LAQ) and a stoichiometry test, partially followed by unstructured interviews to forty Lebanese students (grade II, age 16-20). They derived three main types from tests and interviews. These were:

1. Correct strategies which were subdivided into "algorithmic" "efficient" and "Messy" strategies.
2. Incorrect strategies, which were sub-divided into "incorrect strategies-incorrect answers" and "incorrect strategies – correct answer".
3. Incomplete Strategies as the authors' state, the majority of students participating in this study used algorithmic problem solving even when they do not have adequate understanding of the relevant concepts.

In contrast to results in literature, they did not find a correlation between the factors 'learning approach' and "conceptual understanding". Furthermore they did not find any patterns in the problem solving strategies used by students with different learning approaches. In this study, the relationship between students' academic achievement and practical skills will be investigated.

CHAPTER THREE

METHODOLOGY

3.0 Overview

The chapter described the methodology of the study which was discussed under the following sub-headings: research design, population, sample and sampling procedures, instrument, data collection process and method of data analysis and ethical considerations.

3.1 Research Design

This research is an action research which allows classroom and other school related problems to be studied with the aim of providing immediate interventions to them. Action research (Reason,P and Bradburry,H, 2006), is an interactive inquiry process that balances problem solving actions implemented in a collaborative context with data-driven collaborative analysis or research to understand underlying causes enabling future predictions about personal and organizational change. Action research represents a growing field of educational research whose chief identifying characteristics is the recognition of pragmatic requirements of educational practitioners for organized reflective inquiry into classroom instruction (Hodson, 1993).

The development of the model went through three main stages. The first stage involves identification of the challenges in the teaching and learning of double indicator titration. To do this, a pretest and questionnaire were used to determine the students' knowledge level in double indicator titration. Also chemistry teachers were made to teach the concept double indicator titration in order to determine the teaching strategies used before, during and after the lesson. The teacher was asked to teach the topic "double indicator titration involving HCl against Na_2CO_3/NaOH mixture" to learners. As the teaching and learning is ongoing, the following observations were made;

1. Teacher asked students, what an acid and base is then preceded by writing the topic on the board.
2. Teacher explained that, this type of titration involves two indicators.
3. Teacher gave the formula for calculating the volume of HCl required to neutralise the Na_2CO_3 and NaOH in the mixture respectively as $2Ycm^3$ and $(X-Y)cm^3$ for continuous method, $2(Y-X)cm^3$ and $(2X-Y)\ cm^3$
4. The teacher also wrote the reaction equations taking place in the mixture.
5. The laboratory setup was such that each student is to perform the practical alone.
6. The teaching method used was lecturing.

After the practical section, the students were evaluated using the pretest to know their knowledge level and the effectiveness of the teaching strategy used by the teacher. The pretest score indicated upon the lesson delivered by the teacher;

1. students could only identify double indicator titration by the topic written on the board and not by the practical activities
2. most students could not calculate the volume of HCl required to neutralise all Na_2CO_3 and NaOH in the mixture.
3. most students have no idea of the colour changes at various end points and also could not write tell which equations of reaction is taking place at a particular time

since they don't have the ability to memorise. Overall understanding of the concept was missing.

The second stage of the study comprised the development and formative evaluation of the teacher support material (TSM) through group discussions and class interactions.

From these observations, a lesson plan (DEPTEM) was designed to enhance the teaching and learning of double indicator titration under the following categories,

1. Break the topic into four parts
    a. HCl against NaOH using methyl orange and phenolphthalein indicator separately. These would help the student know the reactions taking place and also the volume of HCl required to neutralise the NaOH as well as the colour change at the end point.
    b. HCl against Na_2CO_3 using methyl orange and phenolphthalein indicator separately. These would help the student know the reactions taking place and also the volume of HCl required to neutralise the Na_2CO_3 as well as the colour change at the end point. The student would learn that the reaction is half-way when using phenolphthalein indicator but that of methyl orange is a complete reaction. Knowing these two titrations, the student would have an idea of equations of reaction taking place, colour change at various endpoints and total volumes of HCl required to neutralise all Na_2CO_3 and NaOH when given a mixture of the two.
    c. HCl against Na_2CO_3/NaOH mixture using methyl orange and phenolphthalein indicator separately (discontinuous method). At these

stage the student brings the knowledge acquired in titration a and b . The student has all the knowledge of what is going to happen before performing the practical.

d. HCl against Na_2CO_3/NaOH mixture using phenolphthalein followed by methyl orange indicator (continuous method). This stage the student brings the knowledge acquired in titration **c**. The student knows that, at the phenolphthalein end point all the NaOH and half of the Na_2CO_3 have been used leaving half of the Na_2CO_3 in solution for the methyl orange titration.

2. Grouping of students.

   Students should be put into groups of five members instead of working in isolation. These would help reduce the problem of inadequacy of apparatus, it will bring about discussing and also improve collaborative learning which will intern enhance performance of girls. Girls are more comfortable with discussing and collaborative learning.

3. Thirdly, the design of the lesson should be in the form of discussion, questioning and answering while the practical is ongoing.

With the above mentioned category, the researcher came up with the lesson design (DEPTEM) as shown.

<u>DEVELOPED PRACTICAL TEACHING MODEL FOR DOUBLE INDICATOR TITRATION (HCl against Na_2CO_3/NaOH Mixture)</u>

Topic

Double Indicator Titration (Na_2CO_3/NaOH Mixture)

Subtopics

- Titration of HCl against NaOH using a single indicator (phenolphthalein or methyl orange).
- Titration of HCl against Na_2CO_3 using a single indicator (phenolphthalein or methyl orange).
- Titration of HCl against Na_2CO_3 using double indicator method (phenolphthalein and methyl orange).
- Titration of HCl against Na_2CO_3/NaOH mixture using a single indicator (phenolphthalein or methyl orange).
- Titration of HCl against Na_2CO_3/NaOH mixture using double indicator method (phenolphthalein and methyl orange).

Objectives

Today we are going to perform titration using two different indicators to determine the exact concentrations of two substances (Na_2CO_3 and NaOH) in a given mixture.

Anticipatory Set

- What is the colour change at the end of titration between HCl & NaOH using methyl orange indicator

- What is the colour change at the end of titration between HCl & Na_2CO_3 using methyl orange indicator
- What is the colour change at the end of titration between HCl & NaOH using phenolphthalein indicator
- What is the colour change at the end of titration between HCl & Na_2CO_3 using phenolphthalein indicator

Write the balanced chemical equations of the following reactions

- Hydrochloric acid + Sodium hydroxide → Sodium chloride + Water
- Hydrochloric acid + Sodium trioxocarbonate(IV) → Sodium chloride + Carbon dioxide + Water
- Hydrochloric acid + Sodium trioxocarbonate(IV) → Sodium chloride + Sodium hydrogen trioxocarbonate(IV)

Collaborative/Cooperative Activity 1

Teacher divides the whole class into six groups of five members each. The groups are labeled **A B C D E F.**

Teacher classifies groups **A B C** as the **methyl orange group** and groups **D E F** as the **phenolphthalein group.**

Teacher supplies each of the groups with the following materials

- Retort stand and clamp
- Burette

- Pipette
- Funnel
- White tiles
- Conical flask
- Acid-base indicator
- An acid solution (HCl)
- A base solution (NaOH)

The acid-base indicator supplied to groups **A B** and **C** should be methyl orange and that supplied to groups **D E** and **F** should be phenolphthalein.

Teacher gives the following instructions to students.

- Put the HCl into the burette and titrate against $25cm^3$ portions of the NaOH solution using two or three drops of the given indicator.
- Repeat the titration until consistent titre values are obtained.
- Tabulate your results and calculate the average volume of acid used
- The average volume of acid used for the methyl orange groups should be V_a , V_b and V_c respectively.
- The average volume of acid used for the phenolphthalein groups should be V_d , V_e and V_f respectively
- The methyl orange indicator groups should calculate their overall average volume of acid used as:

  $V_a + V_b + V_c / 3 = V_0$

- The phenolphthalein indicator groups should calculate their overall average volume of acid used as:

$V_d + V_e + V_f / 3 = V_1$

Discussions 1

Teacher asks the following questions after the activity

Teacher asks students the following questions:

- What is the difference between V_0 and V_1.
- Why is it that $V_0 = V_1$.
- What is the reaction equation between HCl and NaOH when the indicator used is methyl orange?
- What is the reaction equation between HCl and NaOH when the indicator used is phenolphthalein?
- What can you say about the volume of HCl used in the methyl orange group and in the phenolphthalein titrations?
- Then we can say that volume of HCl ≡ NaOH in the methyl orange titration is…………
- Then we can say that volume of HCl ≡ NaOH in the phenolphthalein titration is……….

Collaborative/Cooperative Activity 2

Teacher maintains the same groupings **A B C** as the methyl orange group and **D E F** as the phenolphthalein group.

Teacher supplies all the materials for titration as indicated above with exception of the NaOH solution to each of the groups. In place of NaOH, teacher supplies Na_2CO_3 solution.

Teacher maintains the indicators supplied to each groups. That is teacher gives groups A **B C** methyl orange indicator and groups **D E F** phenolphthalein indicator.

Teacher gives the following instructions to students.

- Put the HCl into the burette and titrate against $25cm^3$ portions of the Na_2CO_3 solution using two or three drops of the given indicator.
- Repeat the titration until consistent titre values are obtained.
- Tabulate your results and calculate the average volume of acid used
- The average volume of acid used for the methyl orange groups should be V_a , V_b and V_c respectively.
- The average volume of acid used for the phenolphthalein groups should be V_d , V_e and V_f respectively
- The methyl orange indicator groups should calculate their overall average volume of acid used as:

  $V_a + V_b + V_c / 3 = V_2$

- The phenolphthalein indicator groups should calculate their overall average volume of acid used as:

$V_d + V_e + V_f / 3 = V_3$

Discussions 2

Teacher asks the following questions after the activity

- What is the difference between V_2 and V_3
- Why is it that $V_3 = 1/2\ V_2$
- What is the reaction equation between HCl and Na_2CO_3 when the indicator used is methyl orange?
- What is the reaction equation between HCl and Na_2CO_3 when the indicator used is phenolphthalein?
- What can you say about the volume of HCl used in the methyl orange group and in the phenolphthalein titrations?
- Then we can say that volume of HCl ≡ Na_2CO_3 in the methyl orange titration is…………
- Then we can say that volume of HCl ≡ 1/2 Na_2CO_3 ≡ $NaHCO_3$ in the phenolphthalein titration is…………
- Can the $NaHCO_3$ produced at the end of phenolphthalein titration be titrated against HCl using methyl orange indicator?

Collaborative/Cooperative Activity 3

Teacher maintains the same groupings **A B C D E** and **F.**

Teacher supplies all materials for titration as indicated in activity 2. In this case, teacher supplies both methyl orange and phenolphthalein indicators to all the groups.

Teacher gives the following instructions to students.

- Put the HCl into the burette and titrate against $25cm^3$ portions of the Na_2CO_3 solution using phenolphthalein as indicator to the point. Do not discard the contents in the flask. Record the titre value.
- Add two drops of methyl orange indicator to the contents of the flask and continue the titration with the HCl until the end point. Record the titre value.
- Repeat the exercise until consistent titre values are obtained.
- Tabulate your results
- Calculate the average volume of HCl used at the phenolphthalein end point.
- Calculate the average volume of HCl used at the methyl orange end point.
- Groups **A B C** should calculate their overall average volume of HCl used at methyl orange and phenolphthalein end points as V_4 and V_5 respectively.
- Groups **D E F** should calculate their overall average volume of HCl used at methyl orange and phenolphthalein end points as V_6 and V_7 respectively.

Discussions 3

Teacher asks the following questions after the activity

- What is the difference between V_4 and V_5
- What is the difference between V_6 and V_7
- Why is that $V_4 = V_5 = V_6 = V_7 = V_3$

- Why is it that $V_4 + V_5 = V_2$
- Why is it that $V_6 + V_7 = V_2$
- What is the reaction equation between HCl and Na_2CO_3 in the first titration when the indicator used is phenolphthalein?
- What is the reaction equation between HCl and Na_2CO_3 in the second titration when methyl orange indicator was added to the resulting solution obtained in the first titration?
- Then we can say that volume of HCl ≡ 1/2 Na_2CO_3 in the phenolphthalein titration (first titration) is…..............
- Then we can say that volume of HCl ≡ $NaHCO_3$ in the methyl orange titration (second titration) is…………

Collaborative/Cooperative Activity 4

Teacher maintains the same groupings **A B C** as the methyl orange groups and **D E F** as the phenolphthalein groups.

Teacher supplies all the materials for titration as indicated above with the exception of the base solution to each of the groups. In place of the base solution, teacher supplies Na_2CO_3/NaOH mixture solution to each group.

Teacher maintains the indicators supplied to each groups. That is teacher gives groups A **B C** methyl orange indicator and groups **D E F** phenolphthalein indicator.

Teacher gives the following instructions to students.

- Put the HCl into the burette and titrate against $25cm^3$ portions of the $Na_2CO_3/NaOH$ solution using two or three drops of the given indicator.
- Repeat the titration until consistent titre values are obtained.
- Tabulate your results and calculate the average volume of acid used.
- Groups **A B C** should calculate their overall average volume of HCl used as V_8
- Groups **D E F** should calculate their overall average volume of HCl used as V_9

Discussions 4

Teacher asks the following questions after the activity

- What is the difference between V_8 and V_9
- Calculate $V_0 + V_2$ and compare it with V_8. What do you realise.
- Calculate $V_1 + V_3$ and compare it with V_9. What do you realise.
- Why is it that $V_8 > V_9$
- What are the reaction equations between HCl and $Na_2CO_3/NaOH$ when the indicator used is methyl orange?
- What are the reaction equations between HCl and $Na_2CO_3/NaOH$ when the indicator used is phenolphthalein?
- Then we can say that volume of HCl ≡ Na_2CO_3 + NaOH in the methyl orange titration is…............
- Then we can say that volume of HCl ≡1/2 Na_2CO_3 + NaOH in the phenolphthalein titration is…............

- Can the $NaHCO_3$ produced at the end of phenolphthalein titration be titrated against HCl using methyl orange indicator?

Collaborative/Cooperative Activity 5

Teacher maintains the same groupings **A B C D E** and **F.**

Teacher supplies all materials for titration as indicated in activity 2. In this case, teacher supplies both methyl orange and phenolphthalein indicators to all the groups.

Teacher gives the following instructions to students.

- Put the HCl into the burette and titrate against $25cm^3$ portions of the Na_2CO_3 solution using phenolphthalein as indicator to the point. Do not discard the contents in the flask. Record the titre value.
- Add two drops of methyl orange indicator to the contents of the flask and continue the titration with the HCl until the end point. Record the titre value.
- Repeat the exercise until consistent titre values are obtained.
- Tabulate your results
- Calculate the average volume of HCl used at the phenolphthalein end point.
- Calculate the average volume of HCl used at the methyl orange end point.
- Groups **A B C** should calculate their overall average volume of HCl used at phenolphthalein and methyl orange end points as V_{10} and V_{11} respectively.
- Groups **D E F** should calculate their overall average volume of HCl used at phenolphthalein and methyl orange end points as V_{12} and V_{13} respectively.

Discussions 5

- What is the difference between V_{10} and V_{12}
- What is the difference between V_{11} and V_{13}
- Compare $V_1 + V_3$ and V_{10}
- Compare $V_1 + V_3$ and V_{12}
- Why is that $V_4 = V_5 = V_6 = V_7 = V_{11} = V_{13} = V_3$
- Then we can say that volume of HCl ≡1/2 Na_2CO_3 + NaOH in the phenolphthalein titration (first titration) is…............
- Then we can say that volume of HCl ≡ $NaHCO_3$ in the methyl orange titration (second titration) is…………

After the lesson plan had been made, it was applied in the teaching and learning of double indicator titration in research school two and subjected to criticisms. the following criticisms were made;

4. The size of the group was large; these will make some of the students lazy and would not take part in the practical. The classroom would be too mechanistic, thus the number of students in a group was reduced to three.
5. The model is time consuming. With this criticism, the researcher explained that, teachers could arrange with students and meet on weekends.
6. The number of teachers during the lesson should be two not one because, the model comes with an observational check list. The researcher explained that, the presence of the laboratory assistant makes the number of teachers two. Thus both can supervise the practical section.

Modifications were made to arrive at a final version (version B), with real evidence of its practicality obtained.

The third stage involves testing the developed practical teaching model. A pretest, posttest, quasi-experimental/control group design was used. Two groups of students participated in the study i.e. the Experimental and Control groups. A pretest was administered to the two groups in order to determine the equivalence of the groups' ability in double indicator titration before the commencement of the treatment. The experimental group was given the treatment i.e. they were taught the concepts in Practical Chemistry using the DEPTEM. The control group was taught the same chemistry practical concepts using the lecture method or the teachers' method.

Furthermore, the regular chemistry class teachers were used for the study in both experimental and control groups. Training was given to the chemistry teacher who took the experimental group on the application of the DEPTEM while the chemistry teacher who took the control group used the conventional method. Since intact stream was used. The experimental stream teacher was given notes of lesson prepared by the researcher while the researcher vetted the lesson plan prepared by the chemistry teacher in the control group to ensure that the teacher did not deviate from the procedures of instructions commonly used by chemistry teachers. DITAST was used for both pre-test and post-test. The treatments consist of teaching a selected chemistry topic: Double Indicator Titration (Na_2CO_3/NaOH Mixture against HCl). The control group was taught the same topic using lecture method. Lesson plans for both the treatment and control group were the same in terms of contents, basic instructional objectives, length of time for teaching and mode of evaluation except for practical activities in the treatment group. The classroom observational checklist was used to check the teaching activities of both the experimental and control groups.

At the end of the five lessons periods, the researcher administered the post test (after reshuffling of the items) to the subjects in the two groups using the DITAST. The scripts from both pre-test and post-test of the two groups were marked and scored using the marking guide. The data collected from the pre-test and post-test of DITAST were analyzed using mean and standard deviation for answering the research questions and the results were shown in Table 4.12.

Observations were made on how teachers use the TSMs, followed with questionnaire to find out how they felt using the TSMs. In addition, ten students of each of the selected SHS were given questionnaire after the use of the TSMs, to get their impressions and to find out whether their learning of double indicator titration by using the DEPTEM-based TSMs was enhanced. The purpose of the observation and the questionnaire for both teachers and students was to collect quantitative data to answer research questions 3, 4 and 5. The analyses of the quantitative data were in the form of description of trends and interpretation of relationship of responses given by the chemistry teachers and students in the questionnaire.

The study sought to identify the characteristics of teacher support materials that can support the teachers to teach double indicator titration in senior high schools. To be able to identify the characteristics, it was necessary to provide descriptive information on the teachers' views about the TSMs through interviews. In addition, it sought to show how the chemistry teachers used the DEPTEM-based TSMs to teach double indicator titration in the senior high schools. In other to do this, observational data of the teachers were gathered while they used the TSMs to interpret the competences exhibited so as to make generalizations about how the TSMs were used.

However, there was the need to gather quantitative information from teachers and students about their experiences in the teaching process and learning gains when the approach was used. This is to know the effect that the use of DEPTEM-based TSMs had on the teachers' teaching and students' learning of double indicator titration in the senior high schools. The chart on the next page summarizes the research design.

First stage

- Identification of some of the challenges students have in double indicator titration using pretest and questionnaires in research school one(RS1)
- Identification of some of the challenges confronting teachers in the teaching and learning of double indicator titration using questionnaires and observational checklist.

Second stage ↓

Designing of a lesson plan (DEPTEM) that caters for the identified challenges

- the lesson divided into five sub lessons
- the lesson plan put students into groups
- the lesson plan considered collaborative learning

↓

- subjecting the designed model to criticisms by using it to teach in research school two (RS2)
- modifications were made with respect to
  a. size of group
  b. duration of the lesson
  c. number of teachers to teach using the model
  d. final version of the lesson plan was made.

Third stage, testing of the effectiveness of the teaching model in research school three (RS3) and research school four (RS4)

EG → O1 → P/At/Ac → X1 → O2 → P/At/Ac

CG → O1 → P/At/Ac → X0 → O2 → P/At/Ac

Figure 3.1 Illustration of the research Design.

Where: EG = Experimental group CG = Control group O1= pretest O2= posttest X1 = Developed Practical Teaching Method (DEPTEM) Xo = Lecture Method P = Performance (practical skills) Ac = Achievement At = Attitude.

3.2 Population

Population is a group of elements or causes, whether individuals, objects or events, that conform to specific criteria and to which we intend to generalize the results of the research (McMillon, J.H., and Schumacher,S., 2000). Also population is the universe of units from which a sample is collected (Cramer,C and Bryman, A, 2001). The target population for the study was all chemistry teachers and students in four senior high schools with two schools located in the Kwaebibirim District and two senior high schools located in the Denkyembuo District of the Eastern Region of Ghana. The population was made up of thirty-six chemistry teachers (having at least first degree in chemistry) and two hundred and seventy-three (273) SHS 2 and 3 chemistry students. SHS 2 and 3 chemistry students were selected because they had been in the school for more than one year and had experienced the teaching methods of chemistry teachers in their schools. But, the first years were excluded because they were not in school as at the time data was gathered.

3.4 Sample and sampling procedures

The sample consisted of twenty-five chemistry teachers in the four SHS which were coded as Research School 1(RS 1), Research School 2 (RS 2) and Research School 3 (RS 3)

The distribution of the number of students in each class of the selected schools is presented in Table 3.1.

Table 3.1: Result of sampling for this study

Selected SHS	Number of chemistry students	Number of chemistry Teachers
Research School 1 (RS 1)	30 (out of 60)	6 (out of 8)
Research School 2 (RS 2)	30 (out of 72)	5 (out of 7)
Research School 3 (RS 3)	30 (out of 56)	4 (out of 6)
Research School 4 (RS 4)	60 (out of 85)	10 (out of 15)
Total	**150**	**25**

Source: Field data, 2016.

Purposive and simple random sampling procedures were used to select respondents for this study.

The purposive sampling (Welman, J.C., and Kruger, S.J., 1999) is considered to be the most important kind of non-probability sampling technique, was used to select the chemistry teachers. They were selected based on the purpose of the study (Schwandt, 2007) thus, those who "have had experiences relating to the phenomenon to be researched" and had the qualities needed for the study were selected. Welman (1999) explained purposive sampling procedure as where the researcher carefully selects the sample to reflect the purpose of the investigation. Similarly, purposive sampling technique involves selecting a sample based on experiences or knowledge of the group to be sampled (Gay, L. R., and Airasian, P. W., 2003). Twenty-five (25) chemistry teachers were purposively selected because of their experience and knowledge in the topic under investigation. The purposive sampling technique also helped the researcher to obtain the needed information (data) for the study (Creswell, 2007).

In the process of using the simple random sampling technique, 'Yes' and 'No' were written on pieces of paper. They were written in accordance with the total number of boys and girls in each school selected. These pieces of paper were then folded and placed in a container where students were made to pick a piece of paper once from the container. Those who picked the 'Yes' for both boys and girls, were those selected to respond to the questionnaires.

3.4 Instruments

Three main instruments used in this study were classroom observational checklist and questionnaire.

3.4.1 Classroom observational checklist

The classroom observational checklist of this study was made up of varying number of sets of action statements which was based on the design of each DEPTEM-based lesson plan. The observational checklist was divided into four sections: lesson introduction; lesson development; lesson application; and lesson closure. It contains only two columns: the Yes and No columns. Classroom observational checklist was used as an instrument because it helped the researcher to check the effectiveness of the teaching methods employed by the chemistry teachers in the sampled schools.

3.4.2 Questionnaire

Semi-structured questionnaire was used to supplement the classroom observational checklist. Questionnaire was selected because all the participants were literate, and therefore could read and respond to the items. Also, questionnaires could be answered more easily and quickly by participants (Ary, D., Jacobs, L. C., Razavieh, A., and Sorensen, C., 2006). Moreover, due to the large number of participants, interviewing all of them would be unrealistic. Two sets of questionnaires were designed for the study; one for chemistry teachers and the other for chemistry students. Both sets of questionnaires were designed to contain open-ended and close-ended items. Thirty-five (35) minutes was given to participants to respond to the questionnaires. To ensure a 100 per cent return rate, the researcher collected the questionnaire on the same day after participants had responded to them. Out of the 175 questionnaires distributed to participants, all of them were retrieved (25 for chemistry teachers and 150 for chemistry students). Therefore, the response rate for this study was 100%.

3.5 Validity and Reliability of the instruments

3.5.1 Validity of the instruments

An instrument is considered valid when there is confidence that it measures what it is intended to measure in a given situation (Punch, 1998). It was therefore necessary for the researcher to be aware of validity and reliability threats from the design stage to the data gathering, data analysis and data reporting stages. The size of the sample for the interview in this study though was small; the purpose was not to generalize from the findings but rather to understand the perceptions of the participants in order to answer the research questions.

Validity of the instruments in this study was taken through face and content validity techniques. To check the face validity of the instrument, the instruments were given to friends to go through. Afterwards, comments from the friends were used to make the necessary corrections before the instrument was administered. In order to enhance the content validity of the instruments, some lectures examined them. After the examination of the instruments vis-à-vis the research questions, these lectures gave their comments and suggested changes, the experts were requested to critically examine and assess all the items of the instrument, paying attention to the following whether:

1. The test items used, what they were meant to test,
2. The Language expression was simple, clear, precise and free from ambiguity,
3. The questions matched the ability of the students and
4. Questions adequately cover the syllabus.

3.5.2 Reliability of the instruments

A pilot test of the instrument was carried out with fifteen (15) chemistry teachers and seven-five (75) chemistry students in Asaman Senior High School in the Eastern Region of Ghana. Asaman Senior High School was selected because it is in the same category with the study schools. These students were not part of the sample for the study. The questions for the pre-test were set from the course content and structured in order to achieve the stated objective at the end of the lesson. Student academic achievements were evaluated using the researcher-created Double Indicator Titration Assessment Test (DITAST). The DITAST consists of ten (10) multiple-choice items for the pre-test and ten (10) compulsory essay type questions. Pre-test was used to measure the starting point or the pre-existing knowledge on the topic (pre-test), measure the learning as a result of the course experience (post-test) and to target any instructional needs to improve the course.

Again, major portion of the DITAST was extracted and modified from the West African Examinations Council past questions (from 1993 to 2011). This was to ensure that their appropriateness measured to the West African academic content standards in practical chemistry. The test items were carefully analyzed to ensure their reliability. Based on the number of test items, the reliability coefficients for the instrument was approximately 0.77 which was considered to be reliable .

3.6 Data Collection Procedures

A letter of authorization from the Department of Science Education of the University of Education Winneba was obtained to carry out the research in the selected schools. The researcher went to the selected schools to meet the headmasters/headmistresses and chemistry teachers to ask for permission and their cooperation to do the study. After sampling the schools for the main research, the researcher had discussions with the chemistry teachers in the four schools to arrange for convenient dates for the administration of the instruments. The researcher explained the nature of the tasks (instruments) to the teachers. The sampled students were administered with the DITAST pre-test before the treatment strategy to the experimental group. The test which lasted 45minutes was supervised by the researcher and the chemistry tutors. DITAST post-test in the form of class test was conducted at the end of administration of the teaching model was supervised by the researcher and chemistry teachers. Students' scores obtained from pre- test and post-test were also recorded and analyzed.

The questionnaires were administered to both chemistry teachers and students after the research period. The study was conducted during normal morning periods. The questionnaires were answered individually and collected back the day they were administered; hence, obtained a 100% return rate. The questionnaire items were then scored based on the responses for the final analysis. With the assistance of class and subject teachers, questionnaires were distributed to the students and they were filled. The researcher passed some vital instructions to them with regard to the whole exercise. The questionnaires were collected after completion from the teachers and students and verified by reading through to see if all items were answered.

3.7 Method of data analysis

Descriptive statistics (frequency, percentage, mean and standard deviation) were the tools used in analyzing the data gathered. Coding schemes were developed using Statistical Package for Social Sciences (SPSS) (version 21) to organize the data into meaningful and manageable categories. These involve the data obtained from the classroom observational checklist, questionnaires and pre and post – test. The categorized data were converted into frequency counts, simple percentages, means and standard deviations and were used to answer the research questions in this study. Portions of the data were subjected to narrative description. The use of descriptive statistical tools in the analysis of the data resulted from the fact that the study was quantitative in nature.

3.8 Ethical considerations

Ethical considerations were addressed at the beginning before starting the interviews. Below were the procedures that were considered under the ethical consideration;

1. An introductory letter from the department of science education, University of Education, Winneba was obtained to enable approval from the various respondents.
2. Any sensitive issues that were distressing to the participants were eliminated.
3. It was made clear to participants that they could terminate the interview at any stage should they felt uncomfortable with certain questions.
4. To ensure confidentiality of the participant's welfare, their identities were protected by not attaching their identities to the comments they made but rather use a code for it and

CHAPTER FOUR

ANALYSIS OF DATA AND PRESENTATION OF RESULTS

4.0 Overview

This chapter focused on the presentation and discussion of results which were discussed under two sections; section one presented the background information of participants and section two comprised of presentation of results of the research questions as well as the discussion of findings.

Section One

4.1 Results on the Background Information of Participants

This section dealt with the demographic data of participants which includes participants' sex, age, academic qualification and teaching experience. These variables were chosen in order to determine whether or not participants would report the same kind of information based on the same variables about the impact of chemistry practical teaching model for teaching double indicator titration. Table 1 presents the demographic data of participants in the study.

Table 4.1: Result of chemistry students' demographic data

		Frequency	Percent (%)
Sex	Male	123	82
	Female	27	18
Age	13-14 years	27	18
	15-17 years	83	55
	18 years +	40	27

Source: Field data, 2016 (Total number of chemistry students =150)

Result from Table 4.1 indicates that, most of the chemistry students (123, (82%)) were males and females (27, (18%)). The results therefore suggest that majority of the chemistry students were boys as compared to girls. This result corresponds with the findings of Sperling (2005). According to Sperling (2005), in Sub-Saharan Africa, majority of girls do not complete primary school and only 17 per cent of girls are enrolled in secondary school (Sperling, 2005). Again, Mulana also stated that in 43 developing countries' secondary gross enrolment figures were under fifty per cent, and in spite of this, girls constituted the majority of children out of school at this level (Muluma, 2006). According to UNESCO (2006) in South Asia only 47 per cent of girls qualify for secondary school and in Sub-Saharan Africa only 30 per cent of secondary-school aged girls enroll in secondary school (UNESCO, 2006).

Likewise, a study (Houphouet-Boigny, 2000) into education provision in Côte d'Ivoire revealed that from 1995-1996 girls represented 42 percent of primary school pupils; 34 percent of students in the first cycle of secondary education; 30 percent of students in the second cycle and 24 percent in higher education (Houphouet-Boigny, 2000). Similarly, it has been estimated that in Ghana only half as many women (6 percent) as against men (12 percent) have attended Secondary or Senior High School (Service, 1999).

Still from Table 4.1, most of the chemistry students (83, (55%)) were between the ages of 15-17 years, as compared to those between 18 years + (40, (27%)) and 13-14 years (27, (18%)). It is clear from the data on age that, all the students were adolescents and issue concerning them should be of great priority to all educational stakeholders since they are the future leaders of this country.

Table 4.2: Results of chemistry teacher's demographic data

		Frequency	Percent
Sex	Male	17	68
	Female	8	32
Age	25-30 years	6	24
	31-36 years	11	44
	37 years +	8	32
Professional/Nonprofessional	Yes	25	100
	No	-	-
Highest Academic Qualification	BSc/B.Ed.	17	68
	MSc/M.Ed./MPhil	10	40
	Others	8	32
Teaching Experience	3-5 years	8	32
	6-10 years	10	40

	11 years +	7	28

Source: Field data, 2016. (Total number of Chemistry teachers =25)

Result from Table 4.2 revealed that, there were more male chemistry teachers (17, (68%)) than females (8, (32%)). The results therefore suggest that majority of the chemistry teachers were males as compared to their female counterparts. However, the results showed that, female chemistry teachers in the Kwaebibirim District of the Eastern Region have been given equal education opportunities in teaching careers. In general, the results on participants' sex indicate that the researcher was not bias in selecting only male or female chemistry teachers for the study.

Again, most of the chemistry teachers (11, (44%)) fell between the age group 31-36 years, followed by 37 years + (8, (32%)) and 25-30 years (6, (24%)). This implies that, all the teachers were in their youthful stage and were likely to have a cordial relationship with the students since all the students were adolescent. This, in a way, is likely to help build good teacher-students relation during teaching and learning in the classroom.

In relation to professional/nonprofessional teachers, result from Table 4.2 revealed that, all the chemistry teachers (25, (100%)) were professional teachers. Also, most of the teachers (17, (68%)) hold BSc/B.Ed. as their highest academic qualification, next to MSc/M.Ed./MPhil (10, (40%)) without any of them having other highest academic qualification. This result implies that, chemistry teachers in the Kwaebibirim District had obtained the pre-requisite (needed) educational background for them to teach at the SHS level. This academic qualification is therefore likely to have an impact (positive) on their teaching methodology or style; hence, improve the academic performance of chemistry students. This finding agrees with that of Van Driel (2001), whose study findings indicated that, the teachers' knowledge base strongly influences all aspects of teaching like preparation, planning and decision making regarding the choice of content to be learnt (VanDriel, 2001).

Finally, result from Table 4.2 indicates that, most of the chemistry teachers (10, (45%)) had 6-10 years teaching experience, followed by 3-5 years (8, (32%)) and 11 years + (7, (28%)). This result suggests that chemistry teachers have not advanced in terms of teaching experience as compared to those who have been in the service for long (30-59 years). It pre-supposes that some of the chemistry teachers were likely to have taught for few years and left the classroom for other jobs, perhaps more lucrative jobs other than teaching. Though in some countries teachers are among the highly paid workers but the situation in Ghana is the exact opposite. It is therefore not surprising that some teachers nowadays undertake courses outside the education sector since it is a requirement by many of the non-governmental organizations (NGOs) who are noted of paying 'good' salaries to their employees.

These findings confirm teacher quality as one and most influential factor on students' academic performance and many a time, academic preparation of teachers, type of certificate, professional learning and years of teaching experience are taken as indicators of teacher quality (Hammond, 2000). But, in this study, only academic qualification (types of certificate) and teaching experience of the teachers were discussed.

Section Two

4.2 Presentation of results of the research questions and discussion of findings

This part dealt with the results of the study in accordance with the research questions. Four research questions were asked in this study and results were presented below:

Research Question One

The first research question was: **"**Which teaching and learning strategies were used by chemistry teachers when teaching double indicator titration at the SHS?" Items 1-5 under section 'B' of the questionnaire for both students and teachers were used to answer this question and the results are show in Tables 2 and 3.

Table 4.3: Result by students on teaching method used by chemistry teachers

	Strongly Disagree		**Disagree**		**Agree**		**Strongly Agree**	
	f	**%**	**f**	**%**	**F**	**%**	**f**	**%**
Chemistry teacher serves as a facilitator during chemistry lessons	57	38	40	27	32	21	21	14
Students do not use their own initiative during chemistry lessons	20	13	23	15	38	25	69	46
Teacher first demonstrates and afterwards students follow suit during chemistry lessons	58	38	32	22	31	21	29	19
Teacher dominates throughout the lesson	17	12	29	19	35	23	69	46
Teacher uses practical activities during chemistry	73	49	43	27	33	22	1	1

lessons
Source: Field data, 2016. (Total Number of chemistry students=150)

Result from Table 4.3 indicates that, most of the chemistry students (73, representing 49%) were strongly against the statement that their chemistry teachers use practical activities during chemistry lessons, followed by those who were against the claim that their teachers first demonstrates and afterwards students follow suit during chemistry lessons (58, representing 38%), chemistry teachers did not serve as a facilitators during chemistry lessons (57, representing 38%). The result further shows that, more than one third of the students strongly agree that their chemistry teachers did not allow them to use their own initiative during chemistry lessons (69, representing 46%) and teachers dominated the lesson throughout (69, representing 46%). This result implies that, there is the likelihood that most of the chemistry teachers in the Kwaebibirim District use the lecture (talk-and-chalk) method instead of the inquiry (learner-centered) approach when teaching lessons in chemistry.

Again, items 1-5 under section 'B' of the questionnaire for chemistry teachers were also used to answer research question one and the results are shown in Table 4.4.

Table 4.4: Results of teaching and learning strategies used by chemistry teachers

	Strongly Disagree		**Disagree**		**Agree**		**Strongly Agree**	
	f	**%**	**f**	**%**	**F**	**%**	**f**	**%**
I serve as a facilitator during chemistry lessons	3	12	5	20	10	40	7	28
I don't allow students to use their own initiative during chemistry lessons	6	24	10	40	5	20	4	16
I first demonstrate and afterwards students	9	36	10	40	2	8	4	16

follow suit during chemistry lessons								
I dominate throughout the chemistry lesson	1	4	4	16	3	12	17	68
I use practical activities during chemistry lessons	5	20	3	12	2	8	15	60

Source: Field data, 2016. (Total Number of chemistry teachers=25)

Result from Table 4.4 shows that, most of the chemistry teachers (15, representing 60%) were in agreement with the statement that, they use practical activities during practical lessons. Again, Table 4.4 result indicates that, more than two-thirds of the teachers (9, representing 36%) were against the assertion that, teachers first demonstrate and afterwards students follow suit during chemistry lessons. The result implies that, most of the teachers were of the view that they use the practical activities as compared to the lecture method in teaching chemistry lessons. But, this result contradicted with those of the students. The reason could have been that, some teachers did not want to report their weaknesses in their teaching practice.

It could therefore be concluded that, majority of the teachers sampled do not use practical activities during teaching and learning of chemistry in the Kwaebibirim District.

Findings of this study agree with that of Chonjo, Osaki, Possi and Mturu (1996); their study findings revealed that traditional teacher-centered lecture (chalk and talk) approach, which emphasizes the transfer of knowledge and skills and rewards memorization, is the predominant teaching format used in secondary schools in Tanzania (Chonjo, M.P, Possi, K.M. & P. Mturu, 1996). Their findings further revealed that, in using this approach, teachers talk most of the time, while students jot down notes mainly for the purpose of passing exams. This method does not allow much room for critical analysis of issues but it makes students to duplicate the notes and give back to the teacher during examinations.

Also, findings of this study confirm that of Osaki (2000), which revealed that most teachers used transmission (chalk and talk) rather than interactive, learner-centered pedagogy (Osaki, 2000). Likewise, findings of teacher-initiated and dominated teacher-student interaction and lecture method as major methods of teaching agree with Ajaja, who made similar findings in different public schools in Delta State, Nigeria (Ajaja, 2009).

Furthermore, findings as indicated in Table 4.4, show that pattern of interaction in most chemistry classrooms is the teacher initiated and dominated teacher-student interaction. This is not in consonant with international standards which recommend that teachers of science plan inquiry-based programme for their students and should also interact with students to focus and support their inquiries, recognize individual differences and provide opportunities for all students to learn (Bence, L.J, Alsop, S., Bowen, S.G, 2009). The findings also fall short to the recommendation of teaching for effective learning (learning with understanding) where students take responsibility of their own learning through active construction and reconstruction of their own meanings for concepts and phenomena (Brass, 2003).

Research Question Two

The second research question was: **"**In what other ways could the teaching and learning of double indicator titration be done? An observational checklist was used to answer this research question and the results are shown on Table 4.5-4.7. Classroom observational checklist was used as an instrument because it helped the researcher to check the effectiveness of the teaching methods employed by the chemistry teachers in the sampled schools.

Table 4.5: Result on Classroom Observational Checklist for Lesson 1

Category	TALLY		
	YES	NO	REMARKS
Lesson Introduction			
1. Teacher asks students to explain what is an acid – base titration		√	
2. Teacher asks students to provide the names of the two most common indicators used in the laboratory	√		
3. Teacher raises questions about the colour change at the end of titration between HCl & NaOH using methyl orange indicator		√	
4. Teacher raises questions about the colour change at the end of titration between HCl & NaOH using phenolphthalein indicator		√	
5. Teacher observes and listens to students as they express their understanding of acid – base titration	√		
6. Teacher group students together to form five students in a group	√		
7. Teacher insists that students takes his suggestion		√	

8. Teacher supplies each group the materials needed for the task	√	
9. Teacher writes the instructions clearly on the board		√
Lesson Development		
10. Teacher moves from group to group	√	
11. Teacher asks students to explain what they are doing		√
12. Teacher makes sure that every student in a group participate fully in the task		√
13. Teacher moves from group to group the second time to ensure that every equipment has been fixed in its right position		√
14. Teacher asks leading questions for students to identify the colour change after each titration	√	
Lesson Application		
15. Teacher asks for the average volume obtained by methyl orange group (V_0) and that obtained by the phenolphthalein group (V_1)	√	
16. Students discusses the average volumes obtained by the two main groups, V_0 and V_1		√
17. Students make 1 minute presentation of why $V_0 = V_1$		√
18. Teacher asks questions to summarize the lesson		√

Category	YES	NO	REMARKS
19. The evaluation questions posed by the teacher cover all the performance based objectives		√	
20. Teacher gives take- home assignment	√		

Source: field data, 2016

Table 4.6: Result on Classroom Observational Checklist for Lesson 2

Category	TALLY YES	 NO	 REMARKS
Lesson Introduction			
1. Teacher asks students to explain what is an acid – base titration	√		
2. Teacher asks students to provide the names of the two most common indicators used in the laboratory	√		
3. Teacher raises questions about the colour change at the end of titration between HCl & NaOH using methyl orange indicator	√		
4. Teacher raises questions about the colour change at the end of titration between HCl & NaOH using phenolphthalein indicator		√	
5. Teacher observes and listens to students as they express their understanding of acid – base titration		√	
6. Teacher group students together to form five students		√	

in a group		
7. Teacher insists that students takes his suggestion		√
8. Teacher supplies each group the materials needed for the task	√	
9. Teacher writes the instructions clearly on the board		√
Lesson Development		
10. Teacher moves from group to group	√	
11. Teacher asks students to explain what they are doing		√
12. Teacher makes sure that every student in a group participate fully in the task		√
13. Teacher moves from group to group the second time to ensure that every equipment has been fixed in its right position		√
14. Teacher asks leading questions for students to identify the colour change after each titration	√	
Lesson Application		
15. Teacher asks for the average volume obtained by methyl orange group (V_0) and that obtained by the phenolphthalein group (V_1)	√	
16. Students discusses the average volumes obtained by the two main groups, V_0 and V_1		√

17. Students make 1 minute presentation of why $V_0 = V_1$		√	
18. Teacher asks questions to summarize the lesson		√	
19. The evaluation questions posed by the teacher cover all the performance based objectives		√	
20. Teacher gives take- home assignment	√		

Source: field data, 2016

Table 4.7: Result on Classroom Observational Checklist for Lesson 3

Category	TALLY		
	YES	NO	REMARKS
Lesson Introduction			
1. Teacher asks students to explain what is an acid – base titration		√	
2. Teacher asks students to provide the names of the two most common indicators used in the laboratory		√	
3. Teacher raises questions about the colour change at the end of titration between HCl & NaOH using methyl orange indicator	√		
4. Teacher raises questions about the colour change at the end of titration between HCl & NaOH using phenolphthalein indicator	√		
5. Teacher observes and listens to students as they		√	

express their understanding of acid – base titration		
6. Teacher group students together to form five students in a group		√
7. Teacher insists that students takes his suggestion		√
8. Teacher supplies each group the materials needed for the task	√	
9. Teacher writes the instructions clearly on the board		√
Lesson Development		
10. Teacher moves from group to group	√	
11. Teacher asks students to explain what they are doing		√
12. Teacher makes sure that every student in a group participate fully in the task		√
13. Teacher moves from group to group the second time to ensure that every equipment has been fixed in its right position		√
14. Teacher asks leading questions for students to identify the colour change after each titration	√	
Lesson Application		
15. Teacher asks for the average volume obtained by methyl orange group (V_0) and that obtained by the phenolphthalein group (V_1)	√	

16. Students discusses the average volumes obtained by the two main groups, V_0 and V_1		√
17. Students make 1 minute presentation of why $V_0 = V_1$		√
18. Teacher asks questions to summarize the lesson		√
19. The evaluation questions posed by the teacher cover all the performance based objectives		√
20. Teacher gives take- home assignment	√	

Source: field data, 2016

Result from Table 4.5, 4.6 and 4.7 shows that, at the introduction stage though the teacher asked students to provide the names of the two most common indicators used in the laboratory, he/she did not revise students' previous knowledge on the topic. The teacher observed and listened to students as they expressed their understanding of acid–base titration but failed to write the instructions clearly on the board for students to follow.

Result from Table 4.5, 4.6 and 4.7 further shows that, at the lesson development stage, teacher was able to move round the groups to observe how the students were performing the experiment. But, teacher did not ask students to explain what they were doing. Also, teacher did not ensure that every student in a group participated fully in the task. Again, teacher did not ensure that equipment has been fixed in its right position. On the contrary, teacher asked leading questions for students to identify the colour change after each titration.

The resulst further shows that, teacher asked for the average volume obtained by methyl orange group and that obtained by the phenolphthalein group at the lesson application stage. But, students were not allowed to discuss the average volumes obtained by the two main groups. More so, evaluation questions posed by the teacher did not cover all the performance based objectives.

From the observational checklist for all the lessons, it was concluded that the lesson was not successful since most of the key factors were not considered by the teacher. This was likely to have negative impact on the understanding of students.

Based on these results it was concluded that, chemistry teachers' method of teaching lesson impacted negatively on the understanding of students. Upon these observations came the DEPTEM, to assist the teaching and learning of double indicator titration at SHS level.

Research Question Three

The third research question was: "How effective is the developed practical model in teaching double indicator titration at the SHS?" Items 6-7 under section 'C' of the questionnaire for both students and teachers were used to answer this question and the results were shown in Tables 4.8-4.11.

Table 4.8: Results of chemistry students on the effectiveness of DEPTEM in teaching double indicator titration

	Frequency	Percent

Students' preference	DEPTEM	134	89
	Teachers' method	16	11

Source: Field data, 2016. (Total number of chemistry students=150)

Result from Table 4.8 showed that, most of the chemistry students (134, representing 89%) preferred the DEPTEM as compared to their teachers' method (16, representing 11%). This result therefore suggest that, chemistry students had better understanding and were able to retain the knowledge gained when the DEPTEM was used as compared to their teachers' method; hence, the model was effective.

Table 4.9: Results of chemistry teachers on the effectiveness of DEPTEM in teaching double indicator titration

		Frequency	Percent
Teachers' preference	DEPTEM	19	76
	Teachers' method	6	24

Source: Field data, 2016. (Total number of chemistry teachers=25)

From Table 4.9, majority of the teachers (19, representing 76%) were of the view that, they preferred the DEPTEM in relation to their own teaching method (6, representing 24%). This implies that chemistry teachers were able to achieve their lesson objectives when the DEPTEM was used more than their won teaching method.

Again, item 7 on the questionnaire for both chemistry students and teachers was used to answer research question two and the results were presented in Tables 4.10 and 4.11.

Table 4.10: Result of chemistry students on the effectiveness of DEPTEM in teaching double indicator titration

	DEPTEM		Teachers' method	
	f	%	f	%
Clarity of procedures	142	95	8	5
Time allocation	137	91	13	9
Group work	141	94	9	6
Explanations	128	85	22	15
Interractiveness	145	97	5	3

Source: Field data, 2016. (Total number of chemistry students=150)

Result from Table 4.10 indicates that, in using the DEPTEM, most of the teachers and students (145, representing 97%) got more opportunity to interact than in using the teachers' method (5, representing 3%). Also, majority of the students were of the view that, the use of DEPTEM help their teachers to clarify procedures (142, representing 95%) more than using the teachers' method (9, representing 6%). Similarly, 141 (94%) chemistry students were of the view that, the use of DEPTEM help them in group work as compared to the teachers' method (9, representing 6%). Lastly, 137 (91%) chemistry students attest to the fact that, the use of DEPTEM help in times allocation in relation to their teachers' method (13, representing 9%). This result therefore suggest that, the use of DEPTEM help chemistry students to improve upon their knowledge and skills in chemistry lessons as compared to the teachers' method; therefore, the DEPTEM was effective in teaching and learning of double indicator titration. Next is the result by the chemistry teachers.

Table 4.11: Result of chemistry teachers on the effectiveness of DEPTEM in teaching double indicator titration

	DEPTEM		Teachers' method	
	f	**%**	**f**	**%**
Clarity of procedures	16	64	9	36
Time allocation	18	72	7	28
Group work	13	52	12	48
Explanations	20	80	5	20
Interractiveness	21	84	4	16

Source: Field data, 2016. (Total number of chemistry teachers=25)

The result from Table 4.11 indicates that, most of the teachers (21, representing 84%) were of the view that DEPTEM helps them to interact with students during teaching and learning as compared to teachers' method (4, representing 16%) , followed by explanations (20, representing 80%) compared to teachers' method (5, representing 20%), time allocation (18, representing 72%) compared to teachers' method (7, representing 28%), clarity of procedures (16, representing 64%) as compared to teachers' method (9, representing 36%) and group work (13, representing 52%) as compared to teachers' method (12, representing 48%). It was therefore concluded based on these results from Tables 4.8-4.11 that, DEPTEM was an effective developed practical model in teaching double indicator titration at the SHS as compared to the teachers' method.

Findings of this study correspond with that of Enya, (2015) who conducted a research into the approaches that can be used to teach chemistry at Senior High schools. The findings indicated that inquiry and guided discovery are the best approach with a mean of

3.33 and 3.70 respectively. Furthermore, findings of this study concur that of Lubben (1995), who posits that interactions between the teacher and the learners and between the learners themselves are a hallmark of a successful lesson or practical and learner centered teaching (Lubben, F.,Campbell,B. and Dlamini,B., 1995).

More so, Harry, (2011) posits that even though laboratory activities breed interest in students' attitude to science education, it does not warrant realization of the goal of science teaching and learning, rather the combination of all the teaching and learning methods should be used due to the variation in the students. Findings of that study further revealed that students need to be encouraged to become deeply involved in the laboratory work so as to develop their skills. Moreover, Lagowski, (1990) conducted a study on student knowledge retention and the findings showed that, students retain 10% of what they read; 26% of what they hear; 30% of what they see; 50% of what they see and hear; 70% of what they say and 90% of something they say while performing a task.

Research Question four

The fourth research question was: **"**In what ways does the use of the developed model influences students' academic performance at SHS?" The researcher explained the nature of the tasks (instruments) to the chemistry teachers. The sampled students were administered with the DITAST pre-test before the treatment strategy to the experimental group. The test which lasted 45 minutes was supervised by the researcher and the chemistry teachers. DITAST post-test in the form of class test was conducted at the end of administration of the teaching model and was supervised by the researcher and chemistry teachers. Students' scores obtained from pre- test and post-test were also recorded and analyzed and the results were shown in Table 4.12.

Table 4.12: Results of mean and standard deviation for the experimental and control groups

		Pretest		Posttest		Mean
Groups	**N**	**Mean**	**Std. Deviation**	**Mean**	**Std. Deviation**	**Achievement Gain**
Treatment	50	8.1463	2.91171	17.3659	2.74551	9.22
Control	100	7.1571	2.31339	10.6714	2.67420	3.51
Mean Diff.		.9892		6.69445		

Source: Field data, 2016. (Total number of chemistry students=150)

Result from Table 4.12 shows that, the experimental pre-test and post-test mean scores were 8.1463 and 17.3659 with standard deviation scores of 2.91171 and of 2.74551 respectively. However the control group has pre-test and post-test mean scores of 7.1571 and 10.6714 with standard deviations scores of 2.31339 and 2.67420 respectively. As shown in Table 4.12, the mean achievement gain for the treatment group is 9.22 while the mean gain in the control group is 3.51 indicating the superiority of treatment group over the control group in using the developed model.

The results therefore suggest that, the chemistry students in the experimental group had a higher mean score in double indicator titration (Na_2CO_3/NaOH mixture) compared to their control group counterparts. This finding implies that method of instruction helped the chemistry students to acquire the necessary knowledge and skills better. Thus, the active involvement of chemistry students in practical activities has given rise to efficient learning, which accounted for the reported significant effect in acquisition of knowledge and skills. It was therefore concluded that, the developed model influenced SHS chemistry students' academic performance positively.

The findings of this study therefore suggest that participation of the students in the class aids retention and makes the lesson more meaningful. This is because as the chemistry students participate and manipulate equipment/materials, they apply their five senses and other skills to their lessons more than when they would have learned in abstraction or remained less active in the class. The findings of this study also imply that chemistry teachers should adopt practical activity method of teaching (student-centered method). The reason had been that students learn better when they are involved in the activity. Thus, activity-based methods enhance understanding of chemistry concepts and increase the ability to acquire science process skills by the learner.

Findings of this study suggest that curriculum planners are expected to plan for conceptual change over period of years. This is because learning involves the restructuring of prior knowledge to gain new ones for effective learning to take place. Therefore, since the use of practical activities enhances students acquisition of knowledge and skills, it follows that curriculum planners can create the awareness of this method in teachers by including it in the chemistry curricula. Also, they should include within the existing subjects contents of the chemistry curriculum, some corresponding indigenous knowledge. They can do this by re-examining the existing units of the subject matter taught in Senior High schools and identifying their corresponding indigenous knowledge and instructional material. This could make the teaching of chemistry more interesting and meaningful to the students.

Findings of this study were in line with the views of previous researchers like, (Nwosu, 2003; Mandor, 2002; Ibe, 2004) who indicated that active participation of the students gave rise to more meaningful and effective learning. Findings of this study were also in agreement with that of Gokhan, Alipasa and Hulya, (2005). A study (Go'khan, D. Alipasa, A.and Hulya, D., 2005) investigated the effects of students achievement of new teaching material developed for the unit "acids and bases". Also, the students' attitudes towards chemistry were explored. The new materials included work sheets base on conceptual instructional method, the sample consisted of thirty eight students. The findings from the posttest indicated that, the students in the experimental group taught with the new teaching material showed significantly greater achievement in the unit acids and bases than did the students in the control group. In addition, the experimental group had a significantly higher score than the control group, with regard to their attitudes towards chemistry. This shows that the implementation of the new material produced better results both in terms of achievement and attitudes.

Research Question Five

The fifth research question sought to investigate if there was a difference between male and female students' academic achievement of concepts in practical chemistry after being exposed to the practical teaching model. To answer this research question, pretest and posttest were conducted for male and female chemistry students after they have been classified into experimental and control groups. Descriptive statistics (mean and standard deviations) scores were recorded after the pretest and posttest and the result was presented in Table 4.13.

Table 4.13: Mean and standard deviation results for experimental and control groups across the sex

			Pretest		Posttest		Mean Achievement Gains
Groups	**Sex**	**N**	**Mean**	**SD**	**Mean**	**SD**	
Treatment	Male	45	8.2174	2.6450	17.521	2.7281	9.30
	Female	10	8.0556	3.2982	17.166	2.8336	9.11
	Mean Diff.		0.1618		0.3550		
Control	Male	78	6.8378	2.2300	10.891	2.1315	4.05
	Female	17	7.5152	2.3864	10.424	3.1920	2.91
	Mean Diff.		-1.3226		.4677		

Source: Field data, 2016. (Total number of chemistry students=150)

Result from Table 4.13 shows that, the pre-test mean scores and standard deviation score for the experimental male and female were 8.2174 and 2.6450; 8.0556 and 3.29835 respectively. Similarly, the post-test mean scores and standard deviation scores for the experimental male and female groups were 17.5217 and 2.72813; 17.1667 and 2.83362 respectively. Also, the pre-test means scores and standard deviation scores for the control male and female were 6.8378 and 2.23002; 7.5152 and 2.38644 respectively. Also, the post-test mean scores and standard deviation score for the control male and female were 10.8919 and 2.13156; 10.4242 and 3.19208 respectively. The mean achievement gains for males and females in the treatment group are 9.30 and 9.11 respectively. In the control group, the gains were 4.05 and 2.91 respectively for males and females.

These results therefore suggest that, there was a difference between male and female students' academic achievement of concepts in practical chemistry after been exposed to the practical teaching model. This finding was not in agreement with the findings of Ibe, who found no difference between instructional method and gender on performance. This reason for the differences in the findings could be that, the other studies (Ibe, 2004), was conducted in Nigeria which has different cultural background as compared to Ghana. The DEPTEM is a collaborative approach to learning which makes it more comfortable for females. Collaborative learning has been observed to enhance achievement of female and African American students (Herreid, 2000). However the difference in the performance of male and female could also be that, the lesson is a laboratory activity which did not favour females. Most women (Eileen, 2013) are not in science due to the laboratory activities.

CHAPTER FIVE

FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.0 Overview

This chapter focused on the major findings, conclusions, recommendations and suggestions for future studies.

5.1 Findings

Findings from this study indicated that students' poor performance in practical chemistry in the Kwaebibirim District of the Eastern Region can be attributed to a number of reasons. First and foremost, chemistry teachers do not use practical activities during chemistry lessons and this had adverse effects on their academic performance. A practical teaching model was developed (DEPTEM) and seen as an effective model in teaching double indicator titration at the SHS as compared to the teachers' method. Furthermore, findings of this study revealed that, the developed model (DEPTEM) influenced SHS chemistry students' academic performance positively in the teaching and learning of double indicator titration. This was evident from the result after the pretest and posttest were conducted. Finally, findings of this study showed that, there exist differences between male and female students' academic achievement of concepts in practical chemistry after been exposed to the practical teaching model.

5.2 Conclusions

Based on the major findings, the following conclusions were drawn;

1. Chemistry teachers in the Kwaebibirim District of the Eastern Region used lecture method in teaching double indicator titration lessons instead of practical activities and this had negative effects on their academic performance.
2. One of the effective models that can be used to improve teaching and learning of double indicator titration is the developed practical teaching model (DEPTEM) as compared to the teachers' method.
3. Chemistry teachers would improve upon the academic performance of chemistry students in double indicator titration when they use the developed practical model (DEPTEM) more.
4. The outcome of the post-test indicated that, the DEPTEM impact differently on the academic performance of SHS male and female chemistry students in the Kwaebibirim District of the Eastern Region.

5.3 Recommendations

It was therefore recommended based on the conclusions that;

Firstly, in-service training should be organized for chemistry teachers who were already on the field of work to use more of the developed practical model (DEPTEM) in relation to the lecture method. Similarly, workshops/seminars/symposiums should be organized for newly recruited teachers on how to use the developed practical model (DEPTEM) since the findings revealed that, it helped in improving the academic performance of chemistry students in the teaching and learning of double indicator titration.

Secondly, chemistry teachers should use teaching methods that would allow chemistry students to participate and manipulate equipment/materials using their five senses and other skills instead of teaching in abstract or allowing them to remain less active in their class. Thus, activity-based methods would enhance their understanding of chemistry concepts and increase their abilities to acquire science process skills during teaching and learning of chemistry.

Thirdly, the government and non-governmental organizations should collaborate with the Ministry of Education to sponsor in producing more of the developed practical model (DEPTEM) for teaching chemistry lessons. This in a way would help improve the academic performance of chemistry students in the Kwaebibirim District of the Eastern Region and the nation at large.

Fourthly, chemistry teachers should consider teaching methods that would equally cater for both male and female chemistry students during chemistry lessons. This would help prevent them from been bias in their lesson delivery; hence, catering for gender differences.

5.4 Suggestions for further studies

Other researchers could consider the following areas if deem appropriate;

1. Investigating SHS chemistry teachers' perception in the use of practical activities in teaching chemistry lessons.
2. The impact of practical activities on the academic performance of SHS students in physics/biology/chemistry.

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APPENDIX A

QUESTIONNAIRE FOR CHEMISTRY STUDENTS

Section A-Bio data of respondents. **Item number….**

1. Sex Male / Female
2. Age …………………

Section B – Students' Knowledge Level of Double Indicator Titration

3. Do you have an idea of double indicator titration?

   Yes No

4. Have you been taken through practical lesson in double indicator titration before?

   Yes No

Section C – Teacher's Method used in Chemistry Practical Lessons

5. Have you been taken through practical lesson in double indicator titration involving a mixture of Na_2CO_3/NaOH against HCl before?

Yes No

6. Describe a chemistry practical lesson your teacher taught recently. Choose one
   a. The mixture of $Na_2CO_3/NaOH$ was in one container and titrated against HCl, using phenolphthalein and methyl orange indicator.
   b. A titration of NaOH and Na_2CO_3 against HCl using phenolphthalein and methyl orange separately were done before the mixture of $Na_2CO_3/NaOH$ was titrated against HCl using the same indicators.

Section D – Effectiveness of the DEPTEM in improving learners' performance

7. From your experience in the DEPTEM used and the previous method used by your teacher, which would you prefer to be used by teachers?

   DEPTEM MY TEACHER'S METHOD

8. Compare the DEPTEM to MY TEACHER'S METHOD. Use the table below to answer.

   Descriptions

   0. No difference

   1. Fairly good

   2. Good

   3. Very good

   4. Excellent

CATEGORY	DEPTEM					MY TEACHER'S METHOD				
	0	1	2	3	4	0	1	2	3	4
Clearity of procedures										
Time allocation										
Group work										
Explanations										
Interractiveness										

9. Any other comments?

……………………………………………………………………………………

APPENDIX B

QUESTIONNAIRE FOR CHEMISTRY TEACHERS

Section A-Bio data of respondents. **Item no……..**

1. Sex Male / Female
2. In what age range do you belong 25 – 30 years

   31 – 36 years

   37 years and above
3. Are you a professional teacher? Yes No
4. What is your highest academic qualification? BSc/B.Ed. MSc/M.Ed./MPhil.

   Other
5. How many years have you been teaching chemistry at the senior high school?

   3-5years 6-10years 11years and above

Section B-Teaching Methods used in Teaching Chemistry

6. Have you taught the lesson double indicator titration before? Yes

   No

10. Have you taught the lesson double indicator titration involving a mixture of Na_2CO_3/NaOH against HCl before?

   Yes No

7. What instructional procedure do you normally use to teach double indicator titration involving a mixture of Na_2CO_3/NaOH against HCl?

   ………………………………………………………………………………………

   ………………………………………………………………………………………

Section C- Using DEPTEM instructional approach

8. Will you prefer the use of **DEPTEM** to the normal way you teach double indicator titration?

   Yes No

9. Compare your instructional approach to the DEPTEM.

   Score using

   0. No difference
   1. Fairly good
   2. Good
   3. Very good
   4. Excellent

CATEGORY	DEPTEM					MY METHOD				
	0	1	2	3	4	0	1	2	3	4
Catering for inadequate laboratory equipment.										

Time allocation										
Group work										
Explanations										
Interractiveness										
Clearity of procedures										

10. Any other comments?

APPENDIX C

Pre and Post-test

Duration : 45minutes.

Answer all questions.

A sample of anhydrous sodium trioxocarbonate (iv) is suspected to be contaminated with sodium hydroxide. The purity of that sample was investigated by volumetric method as follows;

Instructions

F is an aqueous solution of the sodium trioxocarbonate (iv).

G is 0.1 moldm^{-3} HCl solution

A). G was putted into the burette and titrated against 25cm^{3} portions of F using phenolphthalein indicator.

B). G was again titrated against a fresh $25cm^3$ portions of F using methyl orange indicator. In both cases, burette readings were recorded as in the table below.

i. Burette readings using phenolphthalein indicator

burette readings/cm3	1	2	3
Final	15.00	30.30	18.00
Initial	0.00	15.20	0.00
titre value			

ii. Burette readings using methyl orange indicator

burette readings/cm3	1	2	3
Final	24.90	40.30	25.00
Initial	0.00	10.20	0.00
titre value			

Use the information provided above to answer the following questions.

1. What type of titration is demonstrated above?
   a. Back titration
   b. Redox titration
   c. Double indicator titration
   d. Normal acid base titration
2. What would be the colour of the mixture at phenolphthalein end point?
   a. Pink

b. Colorless

c. Orange

d. Blue-black

3. What would be the color of the mixture at methyl orange end point?

a. Pink

b. Colorless

c. Orange

d. Blue-black

4. Calculate the average volume of HCl used at phenolphthalein end point

a. 22.65 cm^3

b. 16.50 cm^3

c. 16.03 cm^3

d. 15.05 cm^3

5. Calculate the average volume of HCl used at methyl orange end point

a. 24.95 cm^3

b. 32.60 cm^3

c. 27.55 cm^3

d. 26.67 cm^3

Use the following equations to answer question 6 and 7

v. $HCl + NaOH \longrightarrow NaCl + H_2O$

vi. $HCl + Na_2CO_3 \longrightarrow NaHCO_3 + NaCl + H_2O$

vii. $HCl + Na_2CO_3 \longrightarrow NaCl + CO_2 + H_2O$

6. What is/are the equation(s) of reaction in the titration using phenolphthalein indicator?
   a. I , II only
   b. II, III only
   c. I, III only
   d. I,II,III only
7. What is/are the equation(s) of reaction in the titration using methyl orange indicator?
   a. I , II only
   b. II, III only
   c. I, III only
   d. I,II,III only
8. Calculate the total volume of HCl required to neutralize all NaOH in the mixture
   a. 19.80 cm^3
   b. 5.15 cm^3
   c. 22.1 cm^3
   d. 5.45 cm^3
9. Calculate the total volume of HCl required to neutralize all Na_2CO_3 in the mixture
   a. 19.80 cm^3
   b. 5.15 cm^3
   c. 22.1 cm^3
   d. 5.45 cm^3

Is the titration continuous or discontinuous method? …………………………….

APPENDIX D

CLASSROOM OBSERVATIONAL CHECKLIST FOR LESSON 1

Category	TALLY		
	YES	NO	REMARKS
Lesson Introduction			
21. Teacher asks students to explain what is an acid – base titration			
22. Teacher asks students to provide the names of the two most common indicators used in the laboratory			
23. Teacher raises questions about the colour change at the end of titration between HCl & NaOH using methyl orange indicator			
24. Teacher raises questions about the colour change at			

the end of titration between HCl & NaOH using phenolphthalein indicator			
25. Teacher observes and listens to students as they express their understanding of acid – base titration			
26. Teacher group students together to form five students in a group			
27. Teacher insists that students takes his suggestion			
28. Teacher supplies each group the materials needed for the task			
29. Teacher writes the instructions clearly on the board			
Lesson Development			
30. Teacher moves from group to group			
31. Teacher asks students to explain what they are doing			
32. Teacher makes sure that every student in a group participate fully in the task			
33. Teacher moves from group to group the second time to ensure that every equipment has been fixed in its right position			
34. Teacher asks leading questions for students to identify the colour change after each titration			
Lesson Application			
35. Teacher asks for the average volume obtained by			

methyl orange group (V_0) and that obtained by the phenolphthalein group (V_1)			
36. Students discusses the average volumes obtained by the two main groups, V_0 and V_1			
37. Students make 1 minute presentation of why $V_0 = V_1$			
38. Teacher asks questions to summarize the lesson			
39. The evaluation questions posed by the teacher cover all the performance based objectives			
40. Teacher gives take- home assignment			

APPENDIX E

CLASSROOM OBSERVATIONAL CHECKLIST FOR LESSON 2

Category	TALLY		
	YES	NO	REMARKS
Lesson Introduction			
1. Teacher quizzes students about the colour change at the end of titration between HCl & Na_2CO_3 using methyl orange indicator			
2. Teacher quizzes students about the colour change at the end of titration between HCl & Na_2CO_3 using phenolphthalein indicator			
3. Teacher asks students to write a balanced chemical			

equation for the reaction between Hydrochloric acid and Sodium trioxocarbonate(IV) in which the products are Sodium chloride, Carbon(IV) oxide and Water			
4. Teacher asks students to write a balanced chemical equation for the reaction between Hydrochloric acid and Sodium trioxocarbonate(IV) in which the products are Sodium chloride, and Sodium hydrogentrioxocarbonate(IV)			
5. Teacher maintains the same groups and the same members			
6. Teacher instructs students to fix their apparatus for activity 2			
Lesson Development			
7. Teacher moves from group to group			
8. Teacher makes sure that every student in a group participate fully in the task			
9. Teacher asks the two main groups(phenolphthalein & methyl orange groups) to compare their average volume of HCl used(V_2 & V_3)			
10. Teacher asks students to indicate relationship between V_2 and V_3			
11. Teacher moves round from group to group to inspect the relationship			

12. Teacher asks students to discuss and explain the relationship between V_2 and V_3			
Lesson Application			
13. Teacher poses questions as to why $V_2 > V_3$			
14. Students discuss whether the phenolphthalein group can continue the titration using methyl orange after the first end point			
Lesson Closure			
15. Students summarize the lesson			
16. Teacher fills where the summary is inadequate			
17. Teacher poses questions based on the performance based objectives to evaluate the lesson			
18. Teacher gives take-home assignment on what has been taught in the lesson			
19. Teacher gives take-home assignment on what to be taught in the next lesson			

APPENDIX F

CLASSROOM OBSERVATIONAL CHECKLIST FOR LESSON 3

Category	TALLY		
	YES	NO	REMARKS
Lesson Introduction			
1. Teacher poses questions based on student's previous knowledge			
2. Teacher demands the take-home assignment on what to be taught today			
3. Teacher leads discussions on the take-home assignment			
4. Teacher quizzes students about the volume HCl to be used			

since the base solution is Na_2CO_3			
5. Teacher introduces the concept of double indicator titration			
6. Teacher writes instructions clearly on the board.			
7. Teacher maintains the same groups and the same members			
8. Teacher instructs students to fix their apparatus for activity 3			
Lesson Development			
9. Teacher moves round from group to group			
10. Teacher makes sure that every student in a group participate fully in the task			
11. Teacher moves round to observe the colour changes of each group			
Lesson Application			
12. Teacher asks students to compare $V_0 + V_2$ and V_4			
13. Teacher asks students to compare $V_1 + V_3$ and V_5			
14. Teacher asks students to explain whether the phenolphthalein group can continue titration using methyl orange just after the phenolphthalein endpoint			
Lesson Closure.			

15. Students summarizes the lesson			
16. Teacher poses questions based on the performance based objectives to evaluate the lesson			
17. Teacher gives take-home assignment to students			

APPENDIX G

CLASSROOM OBSERVATION CHECKLIST FOR LESSON 4

Category	TALLY		
	YES	NO	REMARKS
Lesson Introduction			
1. Teacher poses questions based on student's previous knowledge			
2. Teacher demands the take-home assignment on what to be taught today			
3. Teacher leads discussions on the take-home assignment			
4. Teacher quizzes students about the volume HCl to be used			

since the base solution is Na_2CO_3 /NaOH Mixture.			
5. Teacher writes instructions clearly on the board.			
6. Teacher maintains the same groups and the same members			
7. Teacher instructs students to fix their apparatus for activity 4			
Lesson Development			
8. Teacher moves round from group to group			
9. Teacher makes sure that every student in a group participate fully in the task			
10. Teacher moves round to observe the colour changes of each group			
Lesson Application			
11. Teacher asks students the difference between V_8 and V_9			
12. Teacher asks students to compare $V_0 + V_2$ and V_8			
13. Teacher asks students to compare $V_1 + V_3$ and V_9			
14. Teacher asks students to explain whether the phenolphthalein group can continue titration using methyl orange just after the phenolphthalein endpoint			
Lesson Closure.			
18. Students summarizes the lesson			
19. Teacher poses questions based on the performance based objectives to evaluate the lesson			

20. Teacher gives take-home assignment to students			

APPENDIX J

CLASSROOM OBSERVATION CHECKLIST FOR LESSON 5

Category	TALLY		
	YES	NO	REMARKS
Lesson Introduction			
1. Teacher poses questions based on student's previous knowledge			
2. Teacher demands the take-home assignment on what to be taught today			

3. Teacher leads discussions on the take-home assignment			
4. Teacher quizzes students about the volume HCl to be used since the base solution is Na_2CO_3 /NaOH Mixture.			
5. Teacher writes instructions clearly on the board.			
6. Teacher maintains the same groups and the same members			
7. Teacher instructs students to fix their apparatus for activity 5			
Lesson Development			
8. Teacher moves round from group to group			
9. Teacher makes sure that every student in a group participate fully in the task			
10. Teacher moves round to observe the colour changes of each group			
Lesson Application			
11. Teacher asks students the difference between V_{10} and V_{11}			
12. Teacher asks students the difference between V_{12} and V_{13}			
13. Teacher asks students to compare $V_1 + V_3$ and V_{10}			
14. Teacher asks students to compare $V_1 + V_3$ and V_{12}			
15. Teacher asks students to explain whether any of the titrations could be continued.			
Lesson Closure.			
16. Students summarizes the lesson			
17. Teacher poses questions based on the performance based			

objectives to evaluate the lesson			
18. Teacher gives post- test to students			