UNIVERSITY OF EDUCATION, WINNEBA

EXTENT OF INTEGRATION OF PRACTICAL ACTIVITIES IN TEACHING AND LEARNING OF CHEMISTRY IN GHANAIAN SENIOR HIGH SCHOOLS

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DECLARATION

Student's Declaration

I, **PAUL ASIAMAH BOAKYE**, declare that this thesis, except for quotations and references contained in published works that have all been identified and duly acknowledged, is entirely my original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

Signature: ………..…………………………….

Date: ………..…………………………………

Supervisor's Declaration

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

Name: Professor Kodjo Donkor Taale

Signature: ………..…………………………….

Date: ………..…………………………………

DEDICATION

This work is dedicated to my wife and children, Mad. Lovina Mansah, Katakyie Nana Gyamfi- Asiamah and Oberempomaa Kyeiwaa- Asiamah who sacrificed everything to make this work a successful one.

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This work has been successful due to the assistance and cooperation of so many important personalities.

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ABSTRACT

The study was designed to investigate the extent of integration of practical activities in teaching and learning of chemistry in senior high schools. The study was situated at Secondi-Takoradi Metropolitan area in the Western Region of Ghana. The study adopted an action research design. The researcher used simple random sampling techniques to select seventy (70) participants: twenty (20) Chemistry teachers and fifty (50) students. The data collection instruments used in the study was questionnaire, pre-test and post-test. Analysis of data was carried out using descriptive statistics, correlation analysis and regression analysis. The findings revealed that demonstration experiment and discussion type of practical activity had F-statistic of 14.86 and its associated significance level was found to be 0.000 indicating a significant linear relationship with the dependent variable which is the post-test. The study found the mean pre-test scores and the standard deviation of participants to be (M = 51.73, SD = 12.304), and that of the mean post-test scores and standard deviation computed were (M = 64.80, SD = 14.742). Also, 8(16%) students revealed that they had a little practical activity, 10(20%) half of the time, 11 (22%) had it most of the time while 21 (42%) had practical activities all the time. Moreover, 5(10%) indicated that no time was allocated to Chemistry lesson by demonstration. However, 9(18%) had it a little of the time, 14(28%) half of the time, 16(32%) had it most of the time and 6(12%) had it all the time. Based on the findings of the study, it was recommended that teaching and learning of chemistry in senior high schools should include more practical work. In order to improve their practices, chemistry teachers must receive rigorous in-service training in practical work management and current research. Teachers' pre-service training should include extensive practice in fundamental and higher-order science process abilities so that new teachers are more confident in their ability to use practical work while teaching chemistry and other science concepts. Furthermore, it was recommended that teachers should also be taught how to utilize hand tools so that they can improvise science equipment for practical work as necessary.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This section deals with the background to the study, statement of the problem, purpose of the study, objectives of the study, research questions research hypothesis, significance of the study, delimitation of the study, limitation of the study as well as the organization of the study.

1.1 Background to the Study

Senior High School education is a crucial sub-sector of the entire education system in Ghana as it churns out lower level workers for the economy as well as providing the students that are enrolled into the various tertiary institutions. This implies that the quality of student materials produced by the sub-sector have serious long and short term ramifications on the country and therefore require that this level of education is given the needed attention towards producing quality students who can be compared to students from the other societies (Amponsah, Addo-Mensah, Anokye, Babah, & Etsiwah, 2019). Every country needs a critical mass of educated population, not just in traditional fields such as languages, history, religions, but also in the scientific and technical disciplines that characterize the 21st century (Abdurrahman & Madugu, 2014).

Scientific principles are an important tool required by all nations to assist them in developing technological innovation in the present competitive world. For any nation to develop socially, economically and technologically it requires a strong scientific background. There are several challenges facing the world today which include emergence of new drug resistance, effects of genetic experimentation and engineering, ecological impact of modern technology, dangers of nuclear war and explosions and global warming among others (Vinuesa, et al., 2020).

These challenges have triggered rapid innovation and technological advancement in fields such as communication and agriculture (Walter, Finger, Huber, & Buchmann, 2017). Among the sciences, Science education is instrumental to the development of any nation (Bete, 2020).

It is the reason behind the success in science and technology in the developed world. Chemistry is one of the subjects in science education. It involves the study of matter, its structure, composition, properties and its transformation (Bete, 2020). It plays a key role in the future progress of mankind. The interest and concerns of Chemistry education form the basis of technology (Alabi, 2014).

Chemistry generates fundamental knowledge needed for the technological advancement which will in turn spearhead the economic engineering of the world (National Academies of Sciences, Engineering, and Medicine, 2018). The concept learnt in Chemistry contributes immensely to the technological infrastructure needed to make scientific advances and discoveries (Bete, 2020).

Moreover, Chemistry plays a major role in health education, economic development, energy and environment. The x-rays, radioisotope nuclear resource imaging, laser electron, microscope, synchrotron radiator among other advances in medicine depend on Chemistry (Bete, 2020). The knowledge of Chemistry has contributed to the design of catalytic converter in cars which helps to reduce airborne pollutants that could harm people as well as the environment, turning 90% of harmful emissions into less harmful gasses (Dey, Dhal, Mohan, & Prasad, 2019).

Advances in Chemistry have benefited the transportation industry from building of efficient automobiles, sea vessels, and aeroplanes to navigation using the global positioning system (Barua, Zou, & Zhou, 2020).

Chemistry plays an important role in technological advancement. The principles of Chemistry are the ones which are used in the production of missiles, clinical equipment, and medicine, mining resources, automobile batteries, and processing of fuel (Vijayasarathy, 2018; Boukoberine, Zhou, & Benbouzid, 2019).

Acquisition of Chemistry knowledge and principles helps in various encounter and scientific advancement. The rocket engineering, mobile phones and their attendant spinoff technologies and all other machinery depend on knowledge of Chemistry. Chemistry continues to influence applications in medicine, medical methods including imaging technologies (X- rays, CT- Scanning, ultra-sound, echo techniques, MRI technologies) and diagnostic patient screening techniques are based on Chemistry principles (Boukoberine, Zhou, & Benbouzid, 2019). Continuing research into challenges posed by diseases such as cancer, Ebola, and HIV/AIDS will require the development of high precisions equipment employing Chemistry principles (Li, Leustean, Inci, Zheng, Demirci, & Wang, 2019).

Despite the importance of Chemistry in the scientific and technological development, it appears Chemistry education has been facing various challenges. First, the enrolment in Chemistry course at all levels is low in many African countries (Kinyota, 2020; Chen, Kim, Pan, Tseng, Lin, & Chiang, 2020). Many reasons are advanced for this discrepancy which include inadequate lower level preparations, weak mathematics background, and lack of job opportunities outside the teaching profession, inadequate teacher qualification as well as possession of below standard pedagogical content knowledge (Kinyota, 2020).

Many students consider Chemistry as difficult, abstract and theoretical (Erinosho, 2013). Many students find the subject boring, unemployable (Penn & Ramnarain, 2019) and as a result interest in high school Chemistry is decreasing. Additionally, the students' enrolment is low compared to other sciences (Aina & Adedo, 2013).

In many school curricula little time is allocated for the discipline compared to language and mathematics. In senior high school curriculum in the country, Chemistry is allocated six periods per week whereas English Language and Mathematics are allowed eight and seven lessons per week respectively (Haruna, Salifu, & Mabee, 2018).

In Ghana, the senior high school education takes duration of three years. On joining SHS Form One, the student is taught all the subjects in the curriculum. This means that all the three science subjects that is, Physics, Chemistry and Biology are compulsory. This trend continues in the second year in SHS Form Two. In SHS Form Three students' concentration is then focused on passing the WASSCE. Therefore the study targets SHS Form one and SHS Form Two Chemistry instruction as it is at this crucial point that major decisions that affect the feature of the students and the country at large are made.

Chemistry practical activities focus on the investigations, experiments and demonstrations that can be offered as part of chemistry lessons. A wide range of Chemistry practical works undertaken in senior high schools consist of tried and tested experiments included to stimulate and motivate students (Jabeen & Afzal, 2020). Since chemistry is a practical science, teaching and learning of chemistry should involve chemistry practical work. Chemistry practical work is an essential part of effective science education and science educators have suggested that there are rich benefits in learning from using laboratory activities (Jabeen & Afzal, 2020).

Moreso, Anaso (2017) reports that researchers had observed that lack of chemistry practical work by Chemistry students' results in poor communication as well as observational skills; this gives rise to students' poor performance. Also, good quality chemistry practical work helps in developing students' understanding of scientific processes and concepts (Cahyana, Paristiowati, Savitri, & Hasyrin, 2017).

Chemistry practical work is an essential feature of senior high school science education (Ural, 2016), hence high proportion of chemistry lesson time in senior high school is given to chemistry practical work with assumption that it leads to distinctive attainments in students.

In countries with a tradition of chemistry practical work in school (such as the UK), chemistry practical work is often seen by teachers and others (particularly scientists) as central to the appeal and effectiveness of chemistry study (Ural, 2016). Although many science teachers believe that student chemistry practical work leads to better learning and indeed better performance because we all understand and remember things better if we have done them ourselves, many educators have expressed concern about their effectiveness in promoting learning (Cahyana, Paristiowati, Savitri, & Hasyrin, 2017). For example, Doe (2015) researched on appraisal of the role of laboratory chemistry practical work concluded that, continuing to accord a central role of science teaching to laboratory work does not seem reasonable and feasible any more in the developing countries. Due to arguments such as these and taking into consideration of the relatively high demand for resources and time, then the effectiveness and usefulness of chemistry practical work as a teaching and learning strategy has to be addressed.

Although chemistry courses at all levels have included chemistry practical work where students follow procedures directing them to mix chemicals, make measurements, analyze data, and draw conclusions, Yuliani, Halimatul, Aisyah, and Widhiyanti (2020) argued that the chemistry practical work often consists of what is generally described as 'cook-book' exercises and is often dull and routine, rather than engaging or inspiring. According to Doe (2015) science teachers do not usually find it convenient to make chemistry practical work the centre of their instruction. They usually complain of lack of materials and equipment to carry out chemistry practical work and at the same time, it is possible that some of these materials and equipment may be locked up in the school laboratory store without teachers being aware of their existence.

Although the importance of chemistry practical work in school science is widely accepted, it is also important that the nature of chemistry practical work be supportive to study (Cahyana, Paristiowati, Savitri, & Hasyrin, 2017). For many students, what goes on in the laboratory in form of chemistry practical work is said to contribute little to their learning of chemistry or to their learning about chemistry and its methods (Bete, 2020). According to Mwangi and Mwangi (2016) in their research findings, a verbal, non-practical approach might be best for some teachers and students. Some students may find practical activity a sheer waste of their time. These concerns have led to calls for more 'authentic' practical experiences, or to re-think, re-evaluate, and perhaps reduce, the amount of chemistry practical work to leave more room for other learning activities. Sharpe and Abrahams (2020) maintain that it is time for a reappraisal of the nature, quality, quantity and role of chemistry practical work in the teaching and learning of chemistry.

According to Turner (2017), The House of Commons Science and Technology Committee (UK, 2002) report argued that science practical work is a vital part of science education. They help students to develop their understanding of science, appreciate that science is based on evidence and acquire hands-on skills that are essential if students are to improve in science performance and progress in science. Students should be given the opportunity to do exciting and varied experimental and investigative work. The report highlights the quality of school science practical work and laboratories as key concerns. The report argues that science practical work is a vital part of students' learning experiences and should play an important role in improving students' performance in science. Some sections of the science community, industry and business have expressed concerns that schools in general are not doing enough practical work and that its quality is uneven (Turner, 2017).

In a review of research on chemistry practical work in school science, Sharpe and Abrahams (2020) reports that despite curriculum reform in UK aimed at improving the quality of chemistry practical work students spent too much time following 'recipes' and consequently, practicing lower level skills. Strategies to improve the quality of chemistry practical work have been identified by many authors. For example, Donkor and Justice (2016) pointed out that, effective tasks are those where students are not only 'hands on' but also 'minds on' so that they can make the most of this learning experience.

In opinion of Donkor and Justice (2016), improving the quality of practical activities would be to help teachers become much clearer about the learning objectives of the practical tasks they use. Good quality chemistry practical work promotes the engagement and interest of students as well as developing a range of skills, science knowledge and conceptual understanding.

In reviewing research on chemistry practical work Turner (2017) found out that the amount and quality of chemistry practical work carried out in schools have both suffered as a result of the impacts of national tests in science. For example, according to Sharpe and Abrahams (2020) the assessment regime in England and Wales has had a major impact on the amount and variety of chemistry practicals that teachers carry out.

Literature on school chemistry practical work indicates that there is no clear consensus about the relative merits of chemistry practical work and why we devote so much of our time and limited resources to it (Adu-Gyamfi & Ampiah, 2016). Similarly, Somuah and Orodho (2016) reported that, reviews on research works in this area concluded that science education researchers failed to provide conclusive evidence to support the view that using the laboratory method of teaching science is superior to other methods, at least, as measured by paper and pencil achievement tests.

Blonder, Rap, Mamlok-Naaman, and Hofstein (2015) asserted that research has failed to show a simplistic relationship between experiences provided to the students in the laboratory and learning science. Knowledge of how teaching methods affect students' learning may help educators to select methods that improve the teaching and learning quality and effectiveness. An appraisal of the role of chemistry practical work as an approach or method in the learning and teaching of chemistry is necessary. This can be done by conducting related classroom-based relevant research on central issues like the effectiveness of the method, which can shape and improve chemistry learning consequently improving performance.

While chemistry practical work is assumed to be necessary for all learners, some studies (Hofstein, 2015) show that boys and girls differ in the reception of the practical approach. Although learners benefit through engagement with concepts in chemistry practical work through interactions, hands-on activities and application in science, (Hofstein, 2015) shows that sex may determine students' attitude towards science. A study by Sunny, Taasoobshirazi, Clark, Marchand (2017) showed that boys and girls of the same age tend to have different attitudes to similar teaching styles.

Furthermore, a study by Issah (2016) shows that the attitudes of boys and girls towards science are not different when using similar methods. Due to differing views, this study also sought to find out if there were gender differences in performance when learners were taught chemistry using methods incorporating practical work.

1.2 Statement of the Problem

Chemistry, one of the major sub-areas of Natural Science, is recognised as one of the important sciences that cannot be under-rated in any society that seeks to make significant leaps in science advancement. Chemistry is defined by Ürek and Dolu (2016) as a branch of science that studies matter, its structure, composition, properties and its transformation. It has direct and indirect benefit on society or human life. For instance Chemistry is very pivotal in the pharmaceutical industry, as well as the area of Information Technologies. The knowledge of chemistry has aided man in the areas of fertilisers and insecticides production, which in turn influences food production, preservation and storage for the population. This implies that it is a body of knowledge that deserves to be given all the needed attention in order for society to tap its full benefits (Okorie & Ugwuanyi, 2019).

Unfortunately the subject has not been given the adequate attention and support especially in terms of teaching it practically for students to really appreciate and comprehend its concepts and content well. This according to McCarthy et al., (2015) accounts for the low performance of students in the WASSCE and for that matter its comparatively low application in the larger society.

According to Azure (2015), the consistent low performance of students in the sciences can be attributed to the fact that some teachers still teach the subject theoretically and not practically leading to poor or incomplete comprehension of the concepts the subject embodies. Azure (2015) therefore advised that science is best understood if it is taught practically and the student is also involved in the practical work.

Lately there have been several worries expressed by educational stakeholders and researchers on decline in performance in specific subject areas especially the sciences (Olanipekun & Aina, 2014).

One of the identified science areas where this problem manifests is chemistry. Consistently students' performance in the West African Senior School Certificate Examination (WASSCE) in chemistry has not been too impressive and the yearly results churned out by West African Examinations Council (WAEC) confirm this assertion. Some researchers have blamed this consistent low performance on several factors. Several studies have explored the factors that accounts for decline in academic performance or low performance at the various levels of education (Ogundele, Olanipekun, & Aina, 2014).

Some of the identified causes observed by the researcher in the study area include in-adequate trained chemistry teachers, poor training of chemistry teachers and laboratory technicians, inadequate facilities for teaching the sciences, poor teaching methods and so on (McCarthy et al., 2015). Notable among these possible causes pointed out is inadequate exposure of students to the practical content in chemistry syllabus (Okorie & Ugwuanyi, 2019).

This study therefore seeks to investigate into the level to which the chemistry practical work component is taught in Senior High schools in Ghana's context. It is therefore necessary that how teachers execute the practical components of the chemistry curriculum in the classroom is investigated towards finding appropriate solutions. The key questions that need to be asked are 'to what extent do teachers implement the practical activities in the chemistry curriculum' and 'to what extent are students involved in practical lessons?' This study seeks to address these questions.

1.3 Purpose of the Study

The purpose of this study is to investigate into the extent of integration of practical activities in teaching and learning of chemistry in Ghanaian senior high schools.

1.4 Objectives of the Study

The study research objectives were to:

1. explore the impact of the nature of Chemistry practical activities on Senior High School students' performance in the study area.
2. investigate the effect of practical work in Chemistry on students' performance in Chemistry in the study area.
3. investigate the impact of the quality of Chemistry practical activities on Senior High School students' performance in the study area

1.5 Research Questions

The researcher sought to find answers to the following research questions:

1. What is the impact of the nature of Chemistry practical activities on Senior High School students' performance in the study area?
2. What is the effect of practical activities in Chemistry on students' performance in Chemistry in the study area?
3. What is the impact of the quality of Chemistry practical activities on Senior High School students' performance in the study area?

1.6 Research Hypothesis

The following null hypotheses were tested at a statistical confidence level of 0.05 in the study.

H_{01}: There is no statistically significant difference in performance in Chemistry of students exposed to various types of Chemistry practical activities and when they were not exposed to Chemistry practical activities.

H_{02}: There is no statistically significant difference in performance in Chemistry of students exposed to different qualities of Chemistry practical activities and when they were not exposed to Chemistry practical activities.

1.7 Significance of the Study

Adequate research has confirmed the decline in student's performance in the sciences especially chemistry in Ghana for some time now and it is imperative that an empirical study is conducted to establish the true picture towards addressing the problem. It must not be forgotten that chemistry plays a crucial role in our lives and therefore deserves to be treated with all seriousness if we are to continue tapping its benefit.

The discussions in the study shall bring out the weaknesses in teaching and learning of the subject and shall inform stakeholders on how to refine it appropriately towards improving quality teaching of the subject. The findings of the study can help stakeholders refine the educational system especially in the sciences. Finally, the study intends to inspire research into the research area by providing rich data and literature for future works.

The researcher hopes that the findings of this study would be useful to a number of stakeholders in the education sector. They include Chemistry teachers, Chemistry students, school principals, school laboratory technicians, curriculum developers and future researchers. Since teachers are the curriculum implementers in schools, the findings of the research would sensitize them on better ways of teaching and Chemistry. It would also help them in utilizing existing facilities and in setting new ones. With regard to students, the findings would sensitize them on the importance of the practical component in their studies. School Principals on the other hand will be informed on the various requirements needed in teaching Chemistry and therefore use the findings to sensitize teachers, students and parents on the importance of this practical component in Chemistry.

1.8 Delimitations of the Study

The study shall not cover the all the content areas of chemistry. Any technical discussions that may be presented through this study document are only for the purpose of making the discussion richer and clearer. The study was situated at Secondi-Takoradi Metropolitan area in the Western Region of Ghana due to the fact that the researcher is more familiar with the terrain and can therefore use the familiarity to reach a wider respondent population towards a richer end. Additionally, Simpson, Tetteh, and Agyenim-Boateng (2020) explained that the ultimate means to establish how a system satisfies the user is to ask the stakeholders and the users of that system. Because this study is focused on the subject chemistry in Senior High Schools in Ghana, the respondents shall strictly be heads of departments, teachers and students of chemistry in Senior High Schools.

1.9 Limitations of the Study

The researcher, due to time and costs constraints; narrowed the respondent population to Senior High Schools in the Sekondi-Takoradi Metropolitan area and no other parts of the country, Ghana. The study therefore may not be adequate to generalize the situation in all schools in Ghana.

1.10 Organization of the Study

The report of the study was organized into five chapters. The introductory chapter will comprise the background to the study, the statement of the problem, the purpose of the study, the objectives of the study, research questions, and significance of the study, the delimitation of the study and the limitation of the study.

Chapter two is a review of carefully selected literature on differentiated instruction. It focuses on the conceptual review, theoretical review, empirical review and conceptual frame work of the study.

The research methodology, chapter three, covers the study area, the research design, population of the study, description of the participants, instrument for data collection, data collection procedure and data analysis procedure. The results of the study and its findings are presented in the fourth chapter. The fifth chapter presents a summary of findings, conclusion and recommendations to the study.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Overview

This section deals with the review of the related literature. The review was done under the following sub-headings: Theoretical framework, effectiveness of chemistry practical component taught in senior high schools, level of students' involvement in practical activities in chemistry in senior high schools, chemistry practical content in chemistry syllabus, secondary school chemistry instruction, performance in secondary school chemistry, chemistry practical work and performance in school chemistry, nature of school chemistry practical work quality of school chemistry practical work frequency of school chemistry practical work availability of facilities and equipment in chemistry learning and gender and performance in school chemistry. Conceptual framework that underpinned the study is also presented.

2.2 Theoretical Framework

The study was guided by the constructivist learning theory as postulated by John Dewey who noted that humans generate knowledge and meaning from their experiences (Xyst, 2016; Pardjono, 2016). The theory describes learning as an active, internal process of constructing new understandings. It says that people construct their own understanding and knowledge of the world, through experiencing things and reflecting on those experiences. The learner must play an active role in taking on new knowledge (Adom, Yeboah, & Ankrah, 2016). He or she has to make sense of the experiences and discourse of the chemistry class and use it to construct meaning. This is the constructivist view of learning. The constructivist model suggests that learners construct their ideas and understanding on the basis of series of personal experiences. Learning science at school level is not discovery or construction of ideas that are new and unknown to learners rather it is making what others already know your own (Adom, Yeboah, & Ankrah, 2016).

According to Koki (2019) experiences given during chemistry practical can provide such opportunities for chemistry students. For example, Koki (2019) suggested that, after an illustrative chemistry practical, students are offered explanations, models and analogies from the teacher to help them in their efforts to construct their own understanding of what they have experienced. This study is asking how this happens in senior high school chemistry practical work and how effectively this augments other forms of communication (verbal, pictorial, symbolic) that teachers might use. According to Xyst (2016) and Pardjono (2016) a constructivist model currently serves as a theoretical organizer for many science educators who are trying to understand cognition in science.

According to Van Bergen and Parsell (2019), constructivism provides a perspective on teaching and learning science in classrooms, with a view to improving the effectiveness of science teaching in enhancing students' learning. They argued that, constructivism is the most important theory in science teaching and learning which is providing students with learning environment that promotes their understanding of science by co-constructing and negotiating ideas through meaningful peer and teacher interactions. This study identifies nature, quality and frequency of chemistry practical work as major parts of learning environment which influence construction of chemistry knowledge in secondary school students. The core view of constructivists on learning science suggests that students construct their knowledge strongly influenced by social environments. Therefore, constructivists acknowledge social dimension of learning such as the classroom and community whereby students make meaning of the world through both personal and social processes (Pardjono, 2016).

According to Vilchez (2019), the emphasis of learning activities means two things: student- centered teaching and laboratory-centered teaching. The center of instructional activities is the students themselves, so teacher-centered teaching does little good in students' learning processes. Activities such as performance of experiments (class experiments) and discussion about the results with peers can help students to build understandings. The nature, quality and frequency of the laboratory-centered teaching (chemistry practical work); are crucial in constructing new knowledge and concepts by students. During these laboratory activities, students have opportunities to learn the procedure and skills that are facilitating conceptual changes that may lead to increased performance in chemistry. Constructivism transforms the student from a passive recipient of information to an active participant in the learning process. Research indicates that student achievement and motivation for the study of science improves dramatically if students are active participants in constructing their own knowledge and in learning to use that knowledge to analyze scientific processes (Van Bergen & Parsell, 2019).

Meaningful learning in the laboratory would occur if students were given sufficient time and opportunities for interaction and reflection. Moreover, Alabi (2014), reports that meaningful learning is possible from some given laboratory experiments if the students are given ample opportunities to operate equipment and materials that help them to construct their knowledge of phenomena and related scientific concepts. The construction of deep scientific knowledge results from actively practicing science in structured learning environments, that is, where the nature and quality of laboratory activities are taken into consideration. Senior high schools in the country are categorized into boys', girls' and mixed schools. This categorization implies differing social and cultural learning environments. Individual learners' interactions with their peers are important to each learner's active construction process.

2.3 Effectiveness of Chemistry Practical Component Taught in Senior High Schools

It is widely argued that practical work is essential to teaching and learning in the field of scientific studies and that good quality practical work helps develop students' understanding of scientific processes and concepts (Abdillah, Linuwih, & Isnaeni, 2017). However, whether this has an effect on the attainment scores of the students is still under investigation. In a study conducted to compare the performance of students working in chemistry laboratory with those working in chemistry laboratory supplemented with simulations at secondary school level, where the sample comprised 55 males and 60 female students and 2 Chemistry teachers of public schools; it was found out that there was improvement in the performance of the students of experimental groups which resulted in the rejection of hypotheses that there is no significant difference between the performance of students taught by conventional demonstration in laboratory and laboratory work facilitated with simulation (Farkhanda & Muhammad, 2020).

Moreso, Tettey-Wayo (2018) conducted a study to examine the impact of instructional materials in the teaching and learning of chemistry in senior high schools in the Yilo Krobo and Lower Manya Krobo Municipalities using laboratory apparatus and chemical substances on the topic, acids bases and salts. The main objective of the study was to establish if there is significant difference in academic performance in chemistry between students exposed to chemistry instructional materials and those not exposed. Questionnaires and Students' Chemistry Achievement Test were administered. Inferential statistics, ANOVA and independent T-test were used to test the statistical significance between post-test scores of experimental and control groups with a 0.05 level of significance. It was established that there was a significant difference between the posttest mean score of students exposed to the use of chemistry instructional materials and those not exposed. These findings implied that the use of instructional materials had a significant influence in the performance of chemistry at the senior high school level.

Nonetheless, several studies examining the role of practical work on student attainment investigated many aspects of the quality of the practical work, such as the design of the task given in terms of encouraging students to make links between the theoretical and practical sides. In a study done on a sample of 25 science lessons involving practical work in English secondary schools, the results showed that the practical work supported the direction of the lesson in that it kept students focused on tasks and doing the hands-on work. However, practical work was proven less effective in getting those students to make a connection between concept and application in the lab and reflect on their collected data (Abrahams & Millar, 2008).

The study found that there was insufficient proof that linking concepts to observables is taken into consideration by the people who design these activities for the science lessons. (Pun & Cheung, 2021) proposes that students' minds should be stimulated prior to starting any practical work by providing them with some background information on what it is they are investigating. Also, the task design should direct students' efforts to make links between the two domains of knowledge. Consequently, science teachers should be trained based on the most recent research studies to amend their practices and put forth more time and effort to reflect on linking scientific concepts with the natural world (Chen & Chen, 2021).

However, it is worth noting that the feedback from teachers of laboratory work is a vital source of information about its value. In previous studies, they mentioned that laboratory work is vital for studying sciences but there are certain problems such as: lack of materials needed for the required experiments, insufficient information for carrying out the experiment, insufficient techniques followed during the experiment, lack of information about the glassware and the chemicals that are needed for the experiment, lack of information about safety rules, lack of information about the steps that should be followed to avoid any accident during the experiment and finally what should be done in case of an accident during the experiment (Aydogdu, 2015; Shana & Abulibdeh, 2020).

2.4 Nature of Senior High School Chemistry Practical Activities

Some researchers have discussed the importance of practical activities in science education. The primary goal of practical activity in science education is to offer students with conceptual and theoretical information that will assist students in learning scientific concepts and understanding the nature of science through scientific procedures (Wei & Liu, 2018). Practical activities also allow students to have hands-on experience with science by utilizing scientific research methods. Students should be exposed to scientific theories and their application methods in order to attain meaningful learning. In addition, practical activities promote the development of analytical and critical thinking skills as well as a passion for the science (Farida, Helsy, Fitriani, & Ramdhani, 2018).

Some teachers and students place a high priority on acquiring accurate answers, leaving process skills mastery to chance. In such instances, the breadth of studies is limited, and the perceived demands of evaluated coursework take precedence. However, one of the most significant impediments to improving the quality and variety of practical practice is instructor's time limits and the needs of national assessment. This may require teachers to employ demonstration experiments instead of students' experiments, and teachers may be forced to use drill and practice to prepare students for examination. Regarding the significance of Chemistry practical activities or experiments, there are two opposing viewpoints (Wei & Liu, 2018). The first is that in traditional techniques, students' initiatives and circumstances are given little consideration. All laboratory methods are meticulously detailed in the given manual, and the student is frequently required to simply fill out a well-planned report template. Students have no genuine chance of comprehending or learning the method of doing Chemistry at the end of a practical activity session.

The second is that a student is given the chance to participate in deep learning (Linda, Sulistya, & Putra, 2018). These allows students to define the work's key objectives and plan and execute it, as well as identifies the conceptual and practical challenges that were faced, document and discusses the outcomes and observations, and make practical adjustments and improvements (Linda, Sulistya, & Putra, 2018). As a result, the latter almost always have a big impact on student's capacity to master both the needed practical and the underlying theory (Wei & Liu, 2018). Chemistry experiments should be designed in such a way that they interact with ideas as well as occurrences. Teaching must concentrate on scientific means of talking about and thinking about phenomena rather than the phenomena themselves (Farida, Helsy, Fitriani, & Ramdhani, 2018). To keep students' minds engaged in learning, teachers might use a range of instructional strategies.

According to studies, teaching science through Chemistry practical activities make the subject more entertaining and stimulating for students than teaching the same subject through lecture method (Farida, Helsy, Fitriani, & Ramdhani, 2018). Chemistry practical activities can benefit students in a variety of ways, including enhancing their interest and talents in the topic as well as their Chemistry achievement (Farida, Helsy, Fitriani, & Ramdhani, 2018).

2.5 Chemistry Practical Activities in Senior High Schools: Their Quality

The quality of chemistry practical work varies considerably around the world (Alhammad, 2015; Cruz, Madden, & Asante, 2018). Most curricula specify that practical and investigative activities must be carried out by students. However, there is a gap between policy and practice, between what is written in curriculum documents, what teachers say they do, and what students actually experience. Gudyanga and Jita (2019) found that the lesson objectives stated by teachers frequently failed to be addressed during actual lessons. Despite curriculum reforms aimed at improving the quality of chemistry practical work students spend too much time following recipes and, consequently, practicing lower level skills (Alabi, 2014; Bellou, Papachristos, & Mikropoulos, 2018). Similarly, where students only carry out instructions from worksheets to complete a practical activity, they are limited in the ways they can contribute. As a result, students fail to perceive the conceptual and procedural understandings that were the teachers' intended goals for the laboratory activities (Gudyanga & Jita, 2019). This is a case of under-utilisation of the opportunities provided by practical activities. If teachers do not select appropriate chemistry practical work this may end up in laboratory work of doubtful quality. Such an approach is de- motivating for students and a poor use of teaching and learning resources and which may end up contributing to poor performance in the subject.

2.5 Level of Students' Involvement in Practical Activities in Chemistry in Senior High Schools

The subject chemistry is an important field of science that examines the structure of matter, composition, properties, and the interaction between elements. It enables learners to understand what happens around them. But generally, it is considered a difficult subject to learn due to the great amount of information needed about materials and their properties, which might discourage learners from studying this subject. To understand the properties of all materials and the changes that take place when they interact, many practical applications and experiments must take place in the course of studying this challenging subject. Although practical work is a core component in the subjects of chemistry and biology, some previous researches argued that: (1) Conventional practical work or activities fail to engage students in discussions and do not promote the development of the skills needed to understand chemistry effectively (Listyarini, Pamenang, Harta, Wijayanti, Asyari, & Lee, 2019). (2) If practical work is applied traditionally, then only small groups of students will be involved in this work (Nainggolan, Simamora, & Hutabarat, 2019). (3) Students' discussion during the laboratory work is mainly centered on the procedures needed to carry out the experiment or how to manage lab equipment (Russell & Weaver, 2011; Sandi-Urena, Cooper, Gatlin, & Bhattacharyya, 2011). When it comes to group work in experimental activities in chemistry, the kind of interaction between the members of the group will influence the quality of the group work and level of understanding the experiment, and to some extent the expected outcomes. During group work experiments, it is important that every student has the opportunity to apply what he/she has learned to future tasks to improve his/her learning (Russell & Weaver, 2011; Sandi-Urena et al., 2011) According to Piaget (2013), people construct increasingly sophisticated and powerful representations of the world by acting on them in the light of current understanding. If one considers that Piaget is correct, then practical work is important in understanding sciences in general. The main role of practical work is to give support for students in their learning and to make a link between the domain of real objects and observable facts on one hand and the domain of ideas on the other (Shana & Abulibdeh, 2020).

2.6 Chemistry Practical Aspect in Chemistry Syllabus

In Msimanga, Denley, and Gumede (2017) review of research on science teaching, they identified three rationales generally advanced by those that supported the use of the practical activities in science teaching. The rationales included: 1) The subject matter of science is highly complex and abstract, 2) Students need to participate in enquiry to appreciate the spirit and methods of science 3) Practical work is intrinsically interesting to students. Msimanga, Denley, and Gumede (2017) also compiled a list of objectives of using laboratory work in science teaching. The list included the teaching and learning of skills, concepts, attitudes, cognitive abilities, and understanding the nature of science. Also, there is hardly any science method book that does not usually list the objectives of science laboratory work (McComas, 2017).

All science curricula in Ghana list practical activities that should go with each curriculum item. The West African Examinations Council (WAEC) syllabus (West African Examinations Council (WAEC), 2021) recommended that the teaching of all chemistry concepts listed in the syllabus should be practically based, perhaps, to demonstrate the importance it attached to practical work in chemistry. Thus, emphasizing the assumed importance of practical work in chemistry teaching. This position is, perhaps, why Harshman and Yezierski (2017) thought that science educators should treat practical activities as the ‘meal’ of the main course’ rather than an ‘extra’ or ‘the dessert after a meal’.

Also, Collins (2017) is of the view that all science teachers and students know that practical work is the 'gem' of science teaching. This dogma about the importance of practical activities originated from the views of a few American educationists in the early sixties that extolled the importance of laboratory work in science teaching.

Nevertheless, Sotiriou, Bybee and Bogner (2017) mentioned that traditional practical activities focus solely on scientific terminology and allows students to see only what is happening during experiments, in addition, students may follow instructions written in the laboratory manual step by step which will not give students the chance for creativity and cannot develop their cognitive skills. If students simply follow the lab manual during experiments without connecting it to real life, then the methods will be of no value.

According to Schultz, Callahan, and Miltiadous (2020), the most important negation of cookbook style laboratory does not help students translate scientific outcomes into meaningful learning. Some teachers show doubts regarding the effectiveness of practical work in teaching scientific knowledge. For example, Paterson (2019) stated that: As practiced in many schools, practical activities are ill-conceived, confused and unproductive. For many students, what goes on in the laboratory contributes little to their learning of science. At the root of the problem is the unthinkable use of practical work. Some learners show similar doubts about the effectiveness of practical work in students' learning of chemistry as was found by Paterson (2019). The reason for such criticisms by these learners is that practical work is ineffective for learning a concept or a theory.

According to Sotiriou, Bybee and Bogner (2017), one important condition for the success of inquiry-based learning is that the learning objectives should be clear, concise and easy to follow by the learners. Harshman and Yezierski (2017) mention a scenario where a student in the medical field is exposed to his first X-ray picture and cannot make sense of it. Lecture alone, without seeing an X-ray picture, made it difficult for him to comprehend the results. When finally combining both the theoretical and the practical, everything made more sense to the student. Thus, it can be concluded that in the scientific field practical and theoretical delivery are intertwined and cannot be separated.

2.7 Senior High School Chemistry Instruction

Instruction in chemistry is done through practical work and theory work. Typically, the term practical work means experiences in school settings where students interact with materials to observe and understand the natural world. The practical work is mainly done as student experiments in the laboratory and as teacher demonstrations either in laboratories or in classrooms, while the theory is often done in the classroom (Mwangi & Mwangi, 2016).

Fung, (2015), described chemistry practical work as teacher demonstrations or as class experiments where all learners are on similar tasks, working in small groups or a circus of experiments with small groups of learners engaged in different activities. In secondary schools, Chemistry practical activities are designed and conducted to engage students individually, or in small groups (student experiments) and in large-group demonstration settings (teacher demonstrations) (Cruz, Madden, & Asante, 2018). Successful learning of chemistry depends partly on correct use of a teaching method whose activities target most learning senses. Since chemistry is a subject that encourages hands on experiences, more practical oriented modes of instruction should be selected (Essibu, 2018).

Chemistry practical work is a very prominent feature of school science in many countries and a high proportion of lesson time is given to it. Science practical works are very much a characteristic of the school science curriculum (Vorsah & Adu-Gyamfi, 2021). Chemistry practical work has been part of school science curriculum for over a century, and their place in a chemistry lesson has often gone unquestioned (Fung, 2015). For example, the West African Examinations Council (WAEC) syllabus had over the years recommended that the teaching of all science subjects listed in the syllabus should be practically based, and after several decades of emphasising the assumed importance of practical work activities in science teaching and learning, the importance became elevated to the appreciable level (Abrahams, Reiss, & Sharpe, 2014).

Similarly Koki (2019) argued that, teachers have been socialised by the powerful, myth-making rhetoric of the science teaching profession that sees hands-on practical work in small groups as the universal panacea - the route to all learning goals and the educational solution to all learning problems. Like other sciences, chemistry teaching and learning is supported by laboratory experiments (practical sessions) (Abdurrahman & Madugu, 2014).

Chemistry practical classes (experiments) are believed to help students in understanding theories and chemical principles which are difficult or abstract

(Abrahams, Reiss, & Sharpe, 2014). Moreover, practical work offer several opportunities to students such as: handling of chemicals safely and with confidence, acquiring hands-on experience in using instruments and apparatus, developing scientific thinking and enthusiasm to chemistry, developing basic manipulative and problem solving skills, developing investigative skills, identifying chemical hazards and learning to assess and control risks associated with chemicals (McCarthy, Gyan, Baah-Korang, & McCarthy, 2015; Monica, Nicholas, & David, 2015; Koirala, 2019; Okorie & Ugwuanyi, 2019).

However, Muhaimin, Mukminin, Pratama and Asrial (2019) argue that research has failed to show a simplistic relationship between experiences provided to the students in the laboratory and learning chemistry. There are concerns about the effectiveness of laboratory work in helping the students understand the various aspects of scientific investigation (Pieters, 2010; Abdurrahman & Madugu, 2014).

Teachers usually want to develop students' higher order thinking skills, like critical thinking, through laboratory work; but to what extent they can achieve this is controversial (Le-Eere & Ajoke, 2019; Wafubwa, (2019). Therefore, it is important to analyze the purposes related to Chemistry practical activities, as the purposes need to be well understood and defined by teachers and students alike for the chemistry practical work to be effective. Traditionally, chemistry courses at all levels have included instruction in laboratory settings where students follow procedures directing them to mix chemicals, make measurements, analyze data, and draw conclusions. At the senior high level, and early college levels, chemistry practical work frequently consists of what is generally described as practical exercises (Amponsah, Addo-Mensah, Anokye, Babah, & Etsiwah, 2019). The goals and desired outcomes of chemistry practical work are the subject of considerable debate. Important aspects of the debate center on the value versus cost of any laboratory experience and safety versus hazards of chemicals. Administrators cite these concerns to justify the elimination of chemistry practical work all together (Haruna, Salifu, & Mabee, 2018).

Reports of the Board of Directors of the National Science Teachers Association (NSTA, 1982) in the USA (Abrahams, Reiss, & Sharpe, 2014) recognised that there were widespread doubts about the importance of science practical work in science teaching and learning in the seventies. For example, the national science education standard and other science education literature emphasize the importance of rethinking the role and practice of practical work in chemistry and science teaching in general (Azure, 2015; Amponsah, Addo-Mensah, Anokye, Babah, & Etsiwah, 2019). Likewise, the Ministry of Education in Singapore examined the role that science practical work played in science education to re-evaluate how school science practical work could be made more meaningful and productive for students (Yeşiloğlu & Köseoğlu, 2020). It is due to such concerns that this study seeks to find out the effectiveness of chemistry practical work in chemistry learning with a view of making it more productive and meaningful for learners in the senior high schools in the country.

Teaching and learning of chemistry can also be supported and improved through use of information and communication technology (ICT). ICT is considered as a versatile source of scientific data, theoretical information and offers a viable means to support authentic learning in chemistry (Awad, 2014; Gudyanga & Jita, 2019). Prior to Internet being available, the only learning materials were textbooks, chemistry laboratory facilities and equipment, and the only authority figures were teachers.

However, Awad (2014) reported that there are so many learning materials such as html documents, e-books and electronic encyclopedias in the Internet and also many ways to get in touch with authority figures such as scientists and other school teachers. All what a student may want to know can be obtained through searching the Internet. One of the ICT opportunities in teaching and learning chemistry is to help students to visualize the spatial three-dimensional (3D) elemental and molecular structures, and allows collaborative interactions between teachers and students, and among students themselves (Awad, 2014). Furthermore, these learning technologies expand the range of topics that can be taught in the classroom. The computer and its Internet access extend student-learning experiences beyond the classroom by introducing real-world issues with movies, simulations and animations. They promote contextualized understanding of scientific phenomena in real world. In their research, Sadykov and Ctrnactova (2019) used computer-mediated video clips to show difficult, expensive, time consuming or dangerous demonstrations of real projectile motions. The real-life physical settings depicted in the video clips provided interesting and relevant contexts for students.

2.8 Performance in School Chemistry

The West African Examination Council report on Chemistry from 2014-2019 indicated that the candidates' overall performance in Chemistry and all the science subjects is on the decline (WAEC, 2014; WAEC, 2018; WAEC, 2019). The poor performance in chemistry is not unique to Ghanaian senior high school students only. For example, the biggest challenge facing science educators and researchers in the Caribbean is the underachievement in science subjects among the senior high school students. A review of Caribbean School Examination Council (CSEC) results in biology, chemistry, physics and integrated science for ten years indicated that pass rates had fallen below 50% in these science subjects (Thompson & Soyibo, 2017).

Similarly, international studies of educational performance revealed that USA students consistently rank near the bottom in science and mathematics (Alabi, 2014) is an indication of poor performance in these subjects.

2.9 Chemistry practical work and Performance in School Chemistry

Chemistry practical work is being used in chemistry teaching to support theoretical chemistry instruction. The success of any given chemistry practical task depends on the intended learning objectives of that task. Learning objectives of chemistry practical tasks can be divided into two categories, for example, categories A and B. In category A, the practical tasks should enable the learners to: (i) identify objects (ii) learn a fact(s) (iii) identify phenomena. In Category B, the practical tasks should enable learners to: (i) learn a concept (ii) learn a relationship and (iii) learn a theory/model (McCarthy, McCarthy, Gyan, & Baah-Korang, 2015; Koomson, Safo-Adu, & Antwi, 2020). The science educators' criticisms on chemistry practical work are on tasks with objectives in category (B) and not those in category (A).

Abrahams, Reiss and Sharpe (2014) described the tasks with objectives in category (A) as being effective as many other forms of instruction. The observable aspects of practical tasks are often remembered many months or even years later if the event is a striking one. For example, seeing a piece of sodium put into water (Horner, Miller, Steed, & Sutcliffe, 2016); or the pop sound of burning hydrogen gas.

The role of chemistry practical work is to help students make links between two domains of knowledge: the domain of objects and observable properties and events on the one hand, and the domain of ideas on the other (Horner, Miller, Steed, & Sutcliffe, 2016). The learning objectives of category (B) above are more strongly involved in chemistry practical work than those in category (A). Students are unlikely to grasp a new scientific concept or understand a theory or model (category B objectives) as a result of any single chemistry practical task, however well designed. Students acquire deeper and more extended understanding of an abstract idea or set of ideas in a gradual process, hence the need for frequent and varied practical activities.

Designing practical tasks that animate the students' thinking before they make any observations can make them more effective. One approach which has been found strikingly successful for this is the Predict – Observe – Explain (POE) task structure (Horner, Miller, Steed, & Sutcliffe, 2016). In this approach, students are first asked to predict what they would expect to happen in a given situation and to write this down, then to carry out the task and make some observations, and finally to explain what they have observed (which may or may not be what they predicted). The POE structure makes the practical task more purposeful and to play a pivotal role in students' learning of chemistry and eventually improve performance in the subject. Otherwise a practical task designed to enable the students to observe an object or phenomenon can easily become rather dull and uninspiring, unless it is striking and a memorable one (Horner, Miller, Steed, & Sutcliffe, 2016).

The above role of chemistry practical work in helping students to make links between domains of knowledge: the domain of objects and observable properties and events on the one hand, and the domain of ideas on the other is nowadays being met by using ICT in teaching and learning of chemistry. According to Awad (2014), there is an obvious growth in the importance of information and communication technology (ICT) in science education. ICT is being used as a tool for designing new learning environments, integrating virtual models and creating learning communities (e-learning). Awad (2014) also points out that, the e-learning being used in teaching and learning chemistry, includes informative material in electronic forms such as: www-pages, e-mails and discussion forums enhances the teaching and learning of chemistry. ICT is a versatile source of scientific data, theoretical information and offers a viable means to support authentic learning in chemistry. In teaching and learning of chemistry, ICT helps students to visualize the spatial three-dimensional (3D) elemental and molecular structures, and allows collaborative interactions between teachers and students, and among students themselves (Awad, 2014).

Schools should have teaching websites about high school curricula. These sites should not only offer the video clips showing the lectures and experiments but also many referential learning materials. Internet websites provide student centered learning environments. The control over pacing of computer-based learning gives students the flexibility and times to thoroughly build their understandings of the subject at hand (Basheer, Hugerat, Kortam, & Hofstein, 2016). For example, the use of computer program such as e-chem helps students create more scientifically acceptable representations of molecules (Awad, 2014).

According to Bellou, Papachristos and Mikropoulos (2018), software supports complex processes that students are not capable of completing without assistance. Therefore, extensive use of learning technologies can help students to develop deep understanding of chemistry concepts and processes by themselves and in so doing improve performance in the subject.

The effect of practical work in learning of chemistry in schools may be influenced by several factors. Factors such as nature, quality, and frequency of chemistry practical work facilities and equipment available and gender of the learners among others are leading influences on the teaching and learning of chemistry (Abdurrahman & Madugu, 2014; Azure, 2015; Koki, 2019; Sharpe & Abrahams, 2020). They have crucial roles in determining different attitudes and learning styles of students and consequently different educational impacts on different individuals (Sharpe & Abrahams, 2020). This affects how chemistry instruction takes place in schools and indeed the students' performance in the chemistry examination.

Currently, science educators and teachers agree that laboratory work is indispensable to the understanding of science (Alabi, 2014; Haruna, Salifu, & Mabee, 2018; Chen & Eilks, 2019). The role of laboratory work in science education has been detailed by some researchers (Haruna, Salifu, & Mabee, 2018; Hanson, 2017).

The main purpose of laboratory work in science education is to provide students with conceptual and theoretical knowledge to help them learn scientific concepts, and through scientific methods, to understand the nature of science. Laboratory work also gives the students the opportunity to experience science by using scientific research procedures. In order to achieve meaningful learning, scientific theories and their application methods should be experienced by students. Moreover, laboratory work should encourage the development of analytical and critical thinking skills and encourage interest in science (Haruna, Salifu, & Mabee, 2018).

Teaching and learning of science has over the years tried to mimic what real scientists do. The processes of science, the scientific method, the inquiry process, the content of science and the habits of scientists are all re-contextualized in the science curriculum for schools in many parts of the world (Haruna, Salifu, & Mabee, 2018). In mimicking the real scientist, the rationale for using chemistry practicals as a form of instruction is sometimes forgotten.

Some teachers and students place great emphasis on obtaining the correctness of the answers leaving the mastery of process skills to chance (Haruna, Salifu, & Mabee, 2018). In such cases, the range of investigations is narrowed and is dominated by the perceived demands of assessed coursework. However, the major barrier to improving the quality and variety of practical activity is the constraints felt by teachers in terms of two interrelated factors: time and the demands of the national assessment frameworks. This may force teachers to use demonstration experiments rather than student experiments and sometimes teachers end up in applying drill and practice to train students to pass examinations (Haruna, Salifu, & Mabee, 2018).

Traditional laboratory classes normally involve students carrying out teacher-structured laboratory exercises or/and experiments, where each step of a procedure is vigilantly prescribed and students are expected to follow and adhere to the procedures precisely. This kind of laboratory activity is frequently known as a recipe lab in which little student involvement with the content is required (Essibu, 2018). For such kind of activities, (Horner, Miller, Steed, & Sutcliffe, 2016) add that students can be successful in their laboratory class even with little understanding of what they are actually doing.

Nevertheless, the student may have little option but to accept this passive approach whilst, they deal with new techniques and/or equipment, particularly when the lab preparation involves no more than reading and understanding the laboratory manual. On a similar note, Horner, Miller, Steed and Sutcliffe (2016) commented that the laboratory is regarded as an information overload place, resulting in students with little brain space to process information and consequently, they blindly and thoughtlessly follow the instructions. In addition, they seldom interpret their observations or/and the results obtained during the experiment.

There are two extreme thoughts regarding the importance of Chemistry laboratory experiments/practical work (Achor, Kurumeh, & Orokpo, 2012). The first one is that in traditional approaches, little opportunity is given to student initiatives or circumstance. In this approach, all the laboratory procedures are carefully listed in the provided manual, and frequently the student is simply asked to fill in a well-planned report template. At the end of a laboratory session, students have no real opportunity of understanding or learning the process of doing Chemistry. The second one is that a student is given an opportunity to engage in deep learning (Achor, Kurumeh, & Orokpo, 2012). This would provide a student an opportunity in identifying the main objectives of the work and in planning and executing it, of identifying the conceptual and practical difficulties encountered, recording and discussing the results and observations and of suggesting practical alterations and improvements (Basheer, Hugerat, Kortam, & Hofstein, 2016; Amponsah, Addo-Mensah, Anokye, Babah, & Etsiwah, 2019). The latter, thus, could result in a significant positive impact on a students' ability to learn both the desired practical skills and also the underlying theory (Basheer, Hugerat, Kortam, & Hofstein, 2016).

Chemistry practical work should be conducted in such a way that the students interact with ideas, as much as the phenomena themselves. It is necessary for teachers to focus upon scientific ways of talking and thinking about phenomena, rather than the phenomena themselves (Alhammad, 2015). Teachers can employ a wide variety of teaching strategies to engage students' minds in learning. Reports emphasize that teaching science with the help of chemistry practical work makes chemistry to be more enjoyable and stimulating to students than teaching the same subject matter only through lecture (Abdurrahman & Madugu, 2014). Students have a lot to benefit from chemistry practical work which may include increasing students' interest and abilities in the subject as well as their achievement in chemistry (Amponsah, Addo-Mensah, Anokye, Babah, & Etsiwah, 2019).

2.10 The Frequency of School Chemistry Practical Work

Teachers usually control the frequency and, to some extent, the quality of chemistry practical work in schools. The volume and variety of chemistry practical work in schools has lessened over time (Azure, 2015). In many situations, the cause of this is the focus on teaching for examination, which has squeezed out some types of chemistry practical work. Many teachers complain that, with pressure to get through the syllabus, they cannot find room for many chemistry practical works (Bellou, Papachristos, & Mikropoulos, 2018). Teachers are being required to achieve better examination results and one response to this has been to focus more on book learning which is more easily managed than chemistry practical work. Essibu (2018) reports that teachers had to teach didactically to get through the content according to the examining body specifications.

Practical work in chemistry are expensive, particularly the costs of replenishing apparatus and chemicals. When combined with insufficient budgets to provide enough technical support, materials and equipment and lack of time to prepare the chemistry practical work the frequency of performing practical definitely suffers (Ghani, Ibrahim, Yahaya, & Surif, 2017).

Apart from being expensive on resources and time, student laboratory experiments are more difficult to plan or organize and supervise (Azure, 2015). According to Oakley, Hesmondhalgh, Lee and Nisbett (2014) the National Endowment for Science, Technology and the Arts (NESTA) survey of science teachers (in UK) on factors affecting teachers' use of chemistry practical work found that 64% lacked time for experiments while many teachers said that safety rules had put them off. 87% of respondents said learning which allowed more experiments and scientific enquiry would have a more significant impact on performance. According to Oakley, Hesmondhalgh, Lee and Nisbett (2014) UK science teachers are not alone in reporting lack of time as a barrier to doing more chemistry practical work. For example, a study in Hong Kong, found that science teachers generally find enquiry-based laboratory work very difficult to manage. The high costs and constraints of chemistry practical work limit the number of lessons planned involving chemistry practical and hence the frequency of chemistry practical work goes down.

2.11 Availability of Facilities and Equipment

The place of experimental work in laboratories has always assumed a high profile at all levels of chemical education (Irwansyah, Slamet, & Ramdhani, 2018). Laboratory classes are an ideal place to integrate the active learning approach. Science laboratories have long played a unique role in science education, providing an opportunity for inquiry-based investigative learning (Geleta, 2018). These classes provide an opportunity for hands-on experiences designed to help students further understand concepts learned in the classroom (Irwansyah, Slamet, & Ramdhani, 2018). The modern laboratory provides students opportunities to learn specific procedures and instrumentation and to develop skills such as problem-solving and communication (Geleta, 2018).

In senior high schools where the provision of science laboratories is less than satisfactory, the teaching and learning of chemistry is hindered in a number of ways: (i) when classes are not taught in these specialised rooms, the opportunities to investigate and engage in chemistry practical work are reduced, and hence the effectiveness of teaching, and (ii) timetabling difficulties make the nature and frequency of chemistry practical work and learning more difficult to manage. There is a clear need for the standards of accommodation to be improved and improvement of laboratory stock. If the nature and quality of chemistry practical work are to improve, then there is a continuing need for the upgrading and refurbishment of laboratories, and for new laboratories to be built in schools (Geleta, 2018). Some barriers to effective chemistry practical work associated with facilities include: too many students in practical classes and the associated behavioural problems; insufficient funding being devolved to science departments; under resourced and old fashioned laboratories in schools. These barriers impact heavily on the nature, quality and frequency of chemistry practical work.

2.12 Conceptual Framework

A conceptual framework is a written or visual presentation that explains either graphically, or in narrative form, the main things to be studied, such as, the key factors, concepts or variables and the presumed relationship among them (Eizenberg & Jabareen, 2017). According to Eizenberg and Jabareen (2017), a conceptual framework is a hypothesised model identifying various variables and the relationship among them. The study was based on the assumption that chemistry practical work influence learners' performance in chemistry. Various aspects of chemistry practical work such as, nature, quality and amount of chemistry practical work influence how chemistry practical work affect students' performance in chemistry. These aspects of the independent variable (chemistry practical work) are interconnected to show how they influence the dependent variable (students' performance in chemistry) which constitutes the conceptual framework of the study.

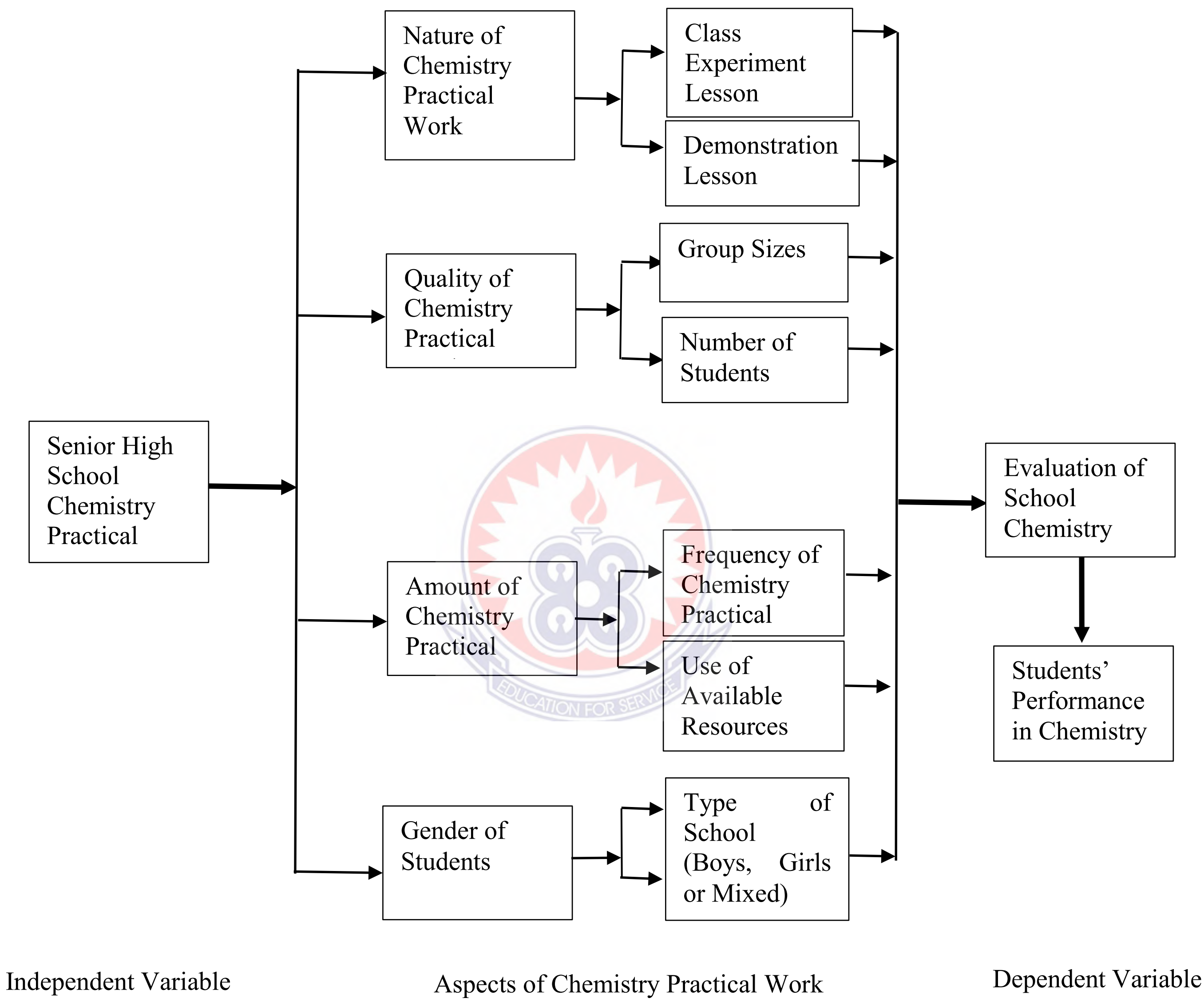


Figure 2.1: A Conceptual Framework on Effect of Chemistry Practical Work on Students' Performance

Chemistry practical work is an approach that is used in the teaching and learning of chemistry. The effectiveness of chemistry practical work as an approach of learning chemistry can be shown by devising chemistry practical work, showing their various aspects and their influences on learning of chemistry at different stages, and then evaluating the students to determine their performance in the subject as Figure 2.1 shows. Nature of chemistry practical work which implies whether the lesson is a class experiment or a demonstration indicates what the students actually do in that lesson. Do they participate by doing the experiment/s or do they just observe it being done?

The resources available in the school will affect the quality of chemistry practical work in that they determine the frequency and the amount of chemistry practical work done and the nature of these practical work. The available resources will also determine the number of groups and their sizes into which students will be divided into. The quality of the chemistry practical work can also be affected by the number students in a class, if too many, the apparatus and reagents may not be enough for all students or the constituted groups would be too large for effective participation in the practical activity. The type of school, that is, whether it is a boys', a girls' or a mixed senior high school determines the kind of social interactions and the attitude of students towards chemistry practical work which may in turn affect their performance in the subject. The achievement of learning objectives is determined by evaluating the students after the learning activities. The performance in the student achievement test (SAT) is an indicator of what the students have learnt and hence an indicator of the effect of the chemistry practical work.

2.13 Summary of the Literature Reviewed

The literature review highlights the need to investigate the effect of chemistry practical work on performance in chemistry in order to establish the effectiveness of chemistry practical work as a teaching and learning strategy in senior high school chemistry. Practical works are a characteristic feature of science teaching at all levels of education. However, Achor, Kurumeh and Orokpo (2012) reported that, questions have been raised by some science educators about the effectiveness of chemistry practical work as a teaching and learning strategy. This brought out the need for a study to find out the effectiveness of chemistry practical and to establish whether the use of chemistry practical work as a teaching learning strategy had an effect on performance of chemistry at senior high school level.

This chapter has included literature review on senior high school chemistry instruction, performance in secondary school chemistry, chemistry practical work and performance in school chemistry, nature of school chemistry practical work, quality of school chemistry practical work, frequency of school chemistry practical work, availability of facilities and equipment for chemistry learning and gender and performance in school chemistry.

The literature review shows that the study was guided by the constructivist learning theory as postulated by John Dewey who noted that humans generate knowledge and meaning from their experiences. The constructivist model suggests that learners construct their ideas and understanding on the basis of series of personal experiences. Personal experiences given during chemistry practical work can provide such opportunities for chemistry students. Additionally, constructivism provides a perspective on teaching and learning science in classrooms, with a view to improving the effectiveness of science teaching in enhancing students' learning. More so, meaningful learning is possible from given laboratory experiments if the students are given ample opportunities to operate equipment and materials that help them to construct their knowledge of phenomena and related scientific concepts and improve performance in the subject.

Moreover, the review indicates that practical activities are a learning experience in which students interact with materials or with secondary sources of data to observe and understand the natural world. Practical work in chemistry has many purposes such as providing students with critical thinking and problem solving skills. Also students handling equipment and materials in chemistry practical lesson enhances their understanding of the real concepts and helps them to conceptualise scientific principles. However, practical activity cannot have any impact on students learning outcomes if they do not develop the right attitudes towards practical work. In this case, attitude defines the feelings, beliefs and values held by students in learning the practical aspects of the subject they are studying. Thus using practical activity in the teaching of chemistry coupled with students developing positive attitude towards learning the subject will improve performance. Performance herein is defined to mean the result of activity either in qualitative or quantitative terms. Following from this conceptual view showed that achievement and skills improved when students are taught chemistry using practical activities outlined in the syllabus. However, as observed, practical work is not done in some schools in the country due to inadequate resources, lack of practical science skills and large classes in science. Learners benefit through engagement with concepts in practical work through interactions, hands-on activities, and application in chemistry. Studies in other jurisdictions including Ghana established that students' performance in chemistry improve when the practical aspects of the subject is properly taught. However, most of these studies did not demonstrate how using practical work can improve the performance of students in chemistry and as such the basis of further research on this subject matter in the Senior High School located in Sekondi-Takoradi Metropolitan area in the Western Region of Ghana.

CHAPTER THREE

METHODOLOGY

3.1 Overview

This chapter discusses the methods and techniques that were used in carrying out the study. The purpose of this study was to investigate into the level of Chemistry practical activities taught in Ghanaian senior high schools in Sekondi-Takoradi Metropolitan area in the Western Region of Ghana. The chapter discussed the study area, research design, population, sample and sampling techniques, sample size determination and sampling procedure, and procedure for data collection and analysis.

3.2 Study Area

The research was carried out in Ghana's Western Region, in the Sekondi-Takoradi Metropolis. In Ghana's Western Region, the Sekondi-Takoradi Metropolis is made up of twenty-two Metropolitan, Municipalities, and Districts. Sekondi is the Metropolis' Administrative Capital (Ghana Statistical Service, 2010). It is approximately 200 kilometers west of Accra, near the coast. The Metropolis is bordered on the East by Shama District, on the North Mpohor District, on the West by Ahanta West District, and on the South by the Gulf of Guinea. With a population of 445, 205 inhabitants, Sekondi-Takoradi is the Region's largest metropolis and an industrial and economic hub (Ghana Statistical Service, 2010). There are various senior high schools, colleges, and special schools in the area, ranging from single-sex to co-educational. Takoradi Technical University, Nurses and Midwifery Training College, and Holy Child College of Education are among the tertiary institutions in the metropolis.

3.3 Research Approach

According to McKenney and Reeves (2018), the three main research approaches are quantitative, qualitative, and mixed methods; based on the type of data the researcher expects, such as textual (non-numeric) data, numeric data, or combination of both. The study must take a quantitative method if the expected data is numeric and a qualitative approach if the data is textual or non-numeric. This study considered mixed methods since it anticipates using both types of data (McKenney & Reeves, 2018). The mixed methods approach is required due to the nature of the study objectives. For example, in order to determine the impact of the nature of Chemistry practical activities on senior high school students' performance in the study area and to determine the impact of the quality of Chemistry practical activities on Senior High School students' performance in the study area, objectives one and three requires the use of qualitative methodologies to compare students' performance. The research objective two aimed at determining quantitative data since it will investigate the effect of practical work in Chemistry on students' achievements in the study area.

3.4 Research Design

According to Jaakkola (2020), a research design is a set of guidelines and instructions that are followed in conducting research. The purpose of the research design is to achieve greater control of the study (Hennink, Hutter, & Bailey, 2020). The study used an action research approach, which aims to identify a solution to a problem that has been recognized in the classroom (Ulvik, Riese, & Roness, 2018). The goal of action research in the classroom is to improve teaching and learning. In action research, the researcher gathers data to diagnose a specific problem, searches for viable solutions, implements the developed solution, and then assesses how well it works (Ulvik, Riese, & Roness, 2018).

On the other hand, action research is a type of disciplined inquiry conducted by a teacher with the goal of informing and changing his or her methods in the future (Clark, Porath, Thiele, & Jobe, 2020). Action research includes instructors selecting a school-based topic or problem to investigate; gathering and evaluating data in order to solve or comprehend a teaching problem; and assisting teachers in understanding parts of their practice (Clark, Porath, Thiele, & Jobe, 2020). Apart from its relevance for this study, action research has other advantages, such as assisting teachers in identifying the obstacles that students confront in teaching and learning circumstances (Ulvik, Riese, & Roness, 2018). Following this line of thought, the action study design provided the researcher with a deeper and more in-depth understanding of the extent to which a practical approach to Chemistry practical work might improve students' overall chemistry performance.

3.5 Research Population

According to Tobin and Steinberg (2015), a study population refers to all the elements that meet the criteria for inclusion in a study. More so, Biesta (2017) referred to a population as the entire group of individuals to whom the findings of a study apply. It is the group that the researcher wishes to explore. All science teachers and students from senior high schools in the Sekondi-Takoradi Metropolis of Ghana's Western Region made up the population of the study. The accessible population, on the other hand, consisted of all Chemistry teachers and students from five Sekondi-Takoradi Senior High schools.

3.6 Sample and Sampling technique

To select a sample from the population for the study, the researcher used simple random sampling technique. From the five senior high schools, a sample of 20 Chemistry teachers and 50 students were randomly selected for the study. Each of the selected senior high school had equal number of students and teachers, with four teachers and ten students from each school.

3.7 Research Instruments

In this research, three (3) instruments were used. The instruments were questionnaire, pre-test and post-test.

3.7.1 Questionnaire

Closed-ended items and Likert scale item questions made up the majority of the questionnaire for this study. The questionnaire was separated into two portions, A and B, to ensure that the research objectives were effectively addressed in the questionnaire. The first section of the questionnaire asked of the respondents' background information. Sex and age were the topics of discussion. Half of the B, the second section, included questions about how to employ a practical approach in teaching the subject. Prior to the intervention, this covered the number of times allotted to practical work in a week in comparison to theoretical aspects of the subjects, the number of times they actually do practical works, methods of teaching/instruction of practical work, students' ability to understand what is being taught, and students' own attitude toward teaching the subject. The questionnaire was administered at the beginning of the study and at the end of the study. The scale was based on a five-point Likert type attitude scale. Strongly disagree (1) disagree (2) don't know (3) agree (4) and strongly agree (5).

3.7.2 Pre-test

Pre-test was used to measure the performance of the learners in Chemistry practical activities of sampled students before the intervention was administered. This was aimed at ensuring that students were of relative same ability in performance in Chemistry. The achievements test was composed of twenty two (22) structured questions.

3.7.3 Post-test

The students' post-test was administered to students after the administration of the intervention. Specific tests evaluating the work done in each topic was given at the end of the topic. These was graded and eventually complied at the end of the term.

3.8 Intervention

During the intervention period which lasted for five weeks at the study area, the researcher prepared a comprehensive teaching lesson notes which was rigidly followed by the researcher and the chemistry teachers of the selected schools captured in the study. The lesson notes captured a lot of classroom practical lessons and teacher demonstration strategies. The students were taught utilising the practical activities. The topics were chosen from the Chemistry syllabus (curriculum) for senior high school. Over the course of the intervention period, the respondents were taught chemistry concepts such as preparation of chlorine gas and reaction of sodium and water using two teaching techniques: classroom practical activities and teacher demonstration strategies. However, in order to stimulate students' cognitive processes, the students were encouraged to share ideas consistently among themselves in groups on the questions provided to them.

During these sessions, students were responsible for completing the tutorial questions on their own, with the researcher and other assisting teachers acting as facilitators. As a result, students were encouraged to work in groups to complete their tasks within the allotted time. The learning strategy was created using the constructivism theory, which indicates that a students' chemistry knowledge will depend on their ability to respond to perceived chemistry problem situations and their solutions by reflecting on them in a social context and constructing or reconstructing mental structures to deal with the situations. The activities during the tutorial sessions followed the instructional cycle of activities, class discussions, and class exercises. The activities in this cycle were designed with a strong emphasis on reflection. Reflective exercises helped students to enhance their thinking skills hence their metacognitive awareness in learning. In addition, the researcher ensured that the quality of reflective activities was tailored to affect and stimulate students' achievement as well as their learning awareness inclined for them to learn better.

Students were exposed to a large number and sample of previous years' examination questions in order to recognize patterns of questions. As a way of preparing them for the post-test, they were encouraged to memorize the patterns. At the end of the intervention, a post-test was administered to the student participants. At the end of the post-test, students' work sheets were collected and graded out of 20 marks; this activity generated a quantitative data which was used in answering the research questions for the study.

3.9 Validity

Validity, according to Vakili and Jahangiri (2018), establishes if the study tools accurately measure what they were designed to measure. To check the questionnaire's substance and face validity, it was submitted to my supervisor (a professor in my field of study), who patiently went through it and made the required suggestions and revisions. To validate the questionnaires and determine the content and face validity of the items, certain Senior Science and English Lecturers from the Department of Science Education and English Education Department of the University of Education of Winneba were consulted to check grammatical errors in the questionnaires.

3.10 Reliability

The Split-Half method was used to examine the reliability of students' pre- and post-tests scores. The pre-test and post-test were divided into two halves using the odd-even items, and the scores were associated or correlated. Based on Pearson's Product Moment Correlation, this resulted in an internal consistency of 0.88. This was then compared with the tabulated dependability or reliability coefficient, which was found to be satisfactory at 0.8 by Vakili and Jahangiri (2018).

3.11 Data Collection Procedure

In the process of collecting data for the study, two (2) National Service Personnel were trained as research assistants on how to use the research tools. They were trained on the procedures to be followed in data collection and demonstration was done by the researcher. The utilisation of the prepared schemes of work that were employed throughout the intervention phase of the study was thoroughly practiced. The research assistants were trained on how to conduct themselves professionally and appropriately when describing the schemes of work or giving the tests. The research assistants' training helped to standardize the data gathering technique by improving consistency.

The researcher and the trained research assistants were in charge of the data collection. The researcher and the research assistants went to the schools that had been chosen for this study. Appointments were made with Chemistry teachers from each of the sampled senior high school to inform them about the nature and significance of the research. A chosen form two topic was taught using a training module that included sample lesson plans and schemes of work. To ensure consistency, the researcher created, produced, and discussed example lesson plans and schemes of work with Chemistry teachers at the chosen schools. Teachers were asked to conduct the pre-test to the sampled students with the help of research assistants before the instruction began in order to determine the learners' entering behaviour. After the pre-test was completed, the research assistants gathered the scripts and submitted them to the researcher for scoring and recording. The researcher graded the pre-test and recorded the results on a scale of one to twenty. In addition, the questionnaires for the teachers were given out at the same time as the pre-test, and the completed ones were collected. The questionnaires were distributed prior to the start of the study to ensure that the teachers' responses were not influenced by the research process. To achieve a higher return rate, the completed questionnaires were collected right away. Following the administration of the pre-test, the relevant chemistry teachers began instructing utilizing the specified and discussed plans of work. The teaching lasted five weeks, during which time the researcher and research assistants visited the participating schools on a regular basis to monitor the implementation of the scheme of work.

During the period of study, all the students in the selected schools were involved in the research process. After the five weeks of teaching, the teachers with the assistance of the research assistants administered the post-test to the students. After the post-test was done, the scripts were collected and forwarded by the research assistants to the researcher for marking and recording the scores. The researcher marked the post-test and recorded the scores out of 20 marks. The questionnaires for the students were administered by the chemistry teachers with the help of the research assistants to the same students after the post-test. The completed questionnaires were collected immediately to ensure a high return rate and were forwarded to the researcher for editing, organization and coding.

3.12 Data Analysis Procedure

The data collected underwent various stages of preparation before the analysis using the Statistical Package for Social Sciences (SPSS) computer software. First, the data were edited and coded. Upon completion of data entry, the data was cleaned to detect and remove any errors committed during data entry. Simple frequency analyses on the variables were run and random cross-tabulation done to clean the data.

Data derived from the study was both quantitative and qualitative. Quantitative data were analysed using Statistical Package for Social Sciences (SPSS) Version 21.0. Quantitative analysis involved presentation of statistical data in form of frequency distribution tables whose explanation was mainly descriptive and inferential statistics. The statistical significance of the results was then examined at a = 0.05 statistical confidence level. Quantitative data was analyzed using independent t-test. For objectives one, two and three, the data derived from the administration of questionnaire and the pre-test and post-test was used to respond to them. Moreover, for the hypotheses, the student's t-test was used to compare if there was significant difference in the means between the pre-tests and post-tests.

3.13 Ethical Considerations

Ethical guidelines were followed when conducting this research. Permission was obtained from the school to gather the data. The fact that the data is only for research purposes was emphasized. In addition, participants were given identification numbers to replace their names. This identification numbers were used to ensure secrecy and anonymity. Every data gathered throughout the study was meticulously stored for the purpose of research.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Overview

This chapter focuses on the analysis of the findings that emerged from the data gathered. The purpose of the study was to investigate into the level of Chemistry practical activities taught in Ghanaian senior high schools. The objectives of the study were to explore the impact of the nature of Chemistry practical activities on senior high school students' performance in the study area, to investigate the effect of practical work in Chemistry on students' achievements in the study area and investigate the impact of the quality of Chemistry practical activities on Senior High School students' performance in the study area.

In furtherance, pre-test, post-test and questionnaire were deployed to gather information from the respondents. The study used both qualitative and quantitative research approaches to analyse the surveyed data. Fifty (50) sampled student-participants and twenty (20) Chemistry teachers from each of the sampled schools responded to the questionnaire.

A total of seventy (70) copies of the questionnaire representing 100 percent retrieval rate was achieved for the questionnaires. Thus, the 70 respondents were used as the final sample and their responses were used in the analysis. The demographic information on the sample and the results obtained are presented in this chapter captured under four main headings which reflected the research questions.

The following research questions underpinned the study:

1. What is the impact of the nature of Chemistry practical activities on Senior High School students' performance in the study area?
2. What is the effect of practical activities in Chemistry on students'

performance in Chemistry in the study area?

3. What is the impact of the quality of Chemistry practical activities on Senior High School students' performance in the study area?

4.2 Demographic Information

The information on the biographic characteristics of the respondents were obtained from the research questionnaire and presented using frequency counts and percentages.

Table 4.1: Demographic characteristics of respondents (N =70)

Variables	Categories	Frequency (F)	Percentage (%)
Student Participants			
Gender	Males	25	50.00
	Females	25	50.00
Total		**50**	**100.0**
Age	15 – 17	25	50.00
	18 – 20	15	30.00
	Above 21	10	20.00
Total		**50**	**100.0**
Teacher Participants			
Gender	Males	15	75.00
	Females	5	25.00
Total		**20**	**100.0**
Age	20 – 25 years	9	45.00
	26 – 30 years	6	30.00
	31 – 40 years	4	20.00
	41 years and above	1	05.00
Total		**20**	**100.0**
Education Level	Degree	16	80.00
	Master Degree	4	20.00
	PHD	0	00.00
Total		**20**	**100.0**
Employment Status	Full Time	15	75.00
	National Service	3	15.00
	Intern	2	10.00
Total		**20**	**100.0**

The result from Table 4.1 reveals the demographic characteristics of students and Chemistry teachers sampled for the study. In Table 4.1, the statistics show that out of

50 respondents on the part of the students, 25 (50%) of the respondents were males while 25 (50%) of them were females. This means that each gender category has been represented equally in the study. From Table 4.1, 25(50 %) of the student participants were between the ages of 15 and 17 years, 15 (30%) were between 18 and 20 years old while 10(20%) were above 21 years. On gender in the teacher participants category, 15(75%) were males while 5(25%) were females. This revelation indicates that majority of the respondents selected for the study were males. This could also mean that very few females venture into the study of Chemistry at the highest level of study. Furthermore, 9(45 %) of the respondents were between the ages of 20 and 25 years, 6 (30%) were between 26 and 30 years. Also, 4(20%) were between 31 and 40 years while those respondents found within the age category of 41 years and above constitute 1(5%).

With regard to highest educational level attained, 16 respondents representing 80% attained first degree in the study of Chemistry. More so, 4(20%) of the participants attained master's degree as their highest educational level in the study of Chemistry while none of the respondent attained PhD in the study of Chemistry. As far as employment status is concerned, 15 respondents representing 75% confirmed that their employment status was full time. 3(15%) of the respondents indicated that they were National Service Personnel while 2(10%) of the respondents were Interns.

4.3 Research Question 1: What is the impact of the nature of Chemistry practical activities on Senior High School students' performance in the study area?

This first research question of the study was to find out the nature of chemistry practical activities on senior high school students' performance. To accomplish this goal, this section discussed the nature of Chemistry practical activities used by

Chemistry teachers in the study area and their impact on students' Chemistry performance, as well as the impact of the nature of Chemistry practical activities on students' Chemistry performance. The data collected with the Section B of the questionnaire was used to answer this study question. The results were presented in the following subheadings or subsections:

4.3.1 Students' Level of Discipline

In order to attain academic success in Chemistry, effective discipline is required in the various classrooms. A school without adequate discipline lacks serene academic environment for both the students and staff to thrive by achieving academic goals. The study wanted to know more about the respondents' discipline. Respondents were asked to rate the level of discipline among their students. The responses were rated on a five-point Likert type scale where 1= very undisciplined 2= undisciplined 3= not sure 4= disciplined and 5= very disciplined. The results are shown in the Table 4.2.

Table 4.2: Students' Level of Discipline (N = 20)

Students' Discipline	Frequency	Percentage (%)
Very disciplined	6	30.00
Disciplined	12	60.00
Not sure	2	10.00
Undisciplined	0	0.00
Very undisciplined	0	0.00
Total	**20**	**100**

The results as presented in Table 4.2 revealed that 12 (60%) of the teachers were of the view that their students were disciplined, moreover, 6(30%) teachers indicated that their students were very disciplined. Only 2(10%) teachers indicated that they were not sure as to whether their students were disciplined. However, as far as undisciplined and very undisciplined were concerned, no participants selected them.

Effective classroom discipline is critical for creating a healthy learning environment and assisting students. Effective teaching and learning can happen when there is effective discipline in the classroom and in the school. If the activities that take place in the Chemistry class are to encourage successful learning, the learners require order in the classroom. The information contained in Table 4.2 suggested that most of the students in the sampled schools were disciplined.

4.3.2 Rating of Students on Academic Abilities

The study sought details on the rating of various academic characteristics by teachers and students themselves. The rating involved the following students' academic characteristics: Academic ability, Academic ability in sciences, academic ability in chemistry and ability in chemistry practical activities. The responses were rated on a five-point Likert scale where 1= very low 2= low 3= average 4= high and 5= very high. Table 4.3 gives the summary of the findings.

Table 4.3: Rating of Students on Academic Abilities (N = 20)

The following academic characteristics were rated		**Very Low**	**Low**	**Average**	**High**	**Very High**
Academic ability	Frequency	0	0	4	10	6
	Percentage (%)	0.00	0.00	20.00	50.00	30.00
Academic ability in sciences	Frequency	2	2	8	5	3
	Percentage (%)	10.00	10.00	40.00	25.00	15.00
Academic ability in chemistry	Frequency	2	4	6	5	3
	Percentage (%)	10.00	20.00	30.00	25.00	15.00
Ability in chemistry practical activities	Frequency	3	5	7	3	2
	Percentage (%)	15.00	25.00	35.00	15.00	10.00

The results indicated in Table 4.3 show the ratings of various students' academic characteristics. The findings indicate that majority of students were above average

(High) in academic ability 10(50%). As far as academic ability in sciences was concerned, majority of the teachers 8(40%) indicated that their students were average. On students' academic ability in chemistry 6(30%) teachers revealed that their students were on the average. Also, regarding ability in chemistry practical activities, 7(35%) of the teachers indicated that their students were average. These data suggest that the students were of average ability, demonstrating that chemistry practical activities can be easily integrated into the classroom and may aid in boosting performance. This means that practical exercises may be utilised to teach students how to follow simple instructions, which is crucial in the development of basic science process skills such as measuring, observation, and recording.

4.3.3 Students' Attitude towards Practical Activities in Chemistry

The study sought to find out the attitude of students towards various activities in chemistry. The responses by students and the chemistry teachers were rated using the Likert scale and the findings presented in Table 4.4.

Table 4.4: Students' Attitude towards Chemistry Aspects (N = 20)

Students' Attitude towards Chemistry Aspects		**Negative**	**Poor**	**Fair**	**Good**	**Excellent**
Science subjects	Frequency	0	10	5	3	2
	Percentage (%)	0.00	50.00	25.00	15.00	10.00
Chemistry subject	Frequency	0	10	7	2	1
	Percentage (%)	0.00	50.00	35.00	10.00	5.00
Chemistry assignments	Frequency	0	9	6	3	2
	Percentage (%)	0.00	45.00	30.00	15.00	10.00
Chemistry practical activities	Frequency	0	7	6	4	3
	Percentage (%)	0.00	35.00	30.00	20.00	15.00
Chemistry theory lessons	Frequency	0	8	7	3	2
	Percentage (%)	0.00	40.00	35.00	15.00	10.00

The results in Table 4.4 indicate the attitudes the students have towards various aspects of chemistry instruction. From the results, majority of the teachers revealed that students showed poor attitude in: chemistry subject 10(50%); chemistry assignment 9(45%); chemistry practical activities 7(35%); and chemistry theory lessons 8(40%), while 10(50%) of the teachers agreed that the students showed poor attitude towards science subject. The findings from Table 4.4 suggests that majority of students in the sampled schools do not take the study of chemistry seriously in the study area. The findings of this study imply that teachers should be much more conscious of the importance of considering and utilising students' views about chemistry practical activities and adopting teaching strategies that would foster and arouse students' interests in the study of Chemistry.

4.3.4 Teachers' Rating of Students' Chemistry Practical Activities

The study examined how teachers rated students in terms of personal qualities related to various aspects of Chemistry practical activities such as making accurate observations, interest in conducting investigations, use of theory in conducting investigations, keeping neat and accurate records, ability to make interpretations and predictions, eagerness to investigate after school, and eagerness to relate observations to theory work. The responses were evaluated using a Likert type scale. The frequency and percentage of the responses were computed and presented in Tables 4.5.

Table 4.5: Teachers' Rating of Students' Chemistry Practical Activities

Teachers' Rating of Students' Chemistry Practical Activities		Very weak	Weak	Average	Strong	Very strong
Making accurate observations	Frequency	4	5	7	2	2
	Percentage (%)	20.00	25.00	35.00	10.00	10.00
Interest in doing investigation	Frequency	1	4	12	2	1
	Percentage (%)	5.00	20.00	60.00	10.00	5.00
Using theory when doing investigations	Frequency	4	5	7	3	1
	Percentage (%)	20.00	25.00	35.00	15.00	5.00
Keeping neat and accurate records	Frequency	3	9	6	1	1
	Percentage (%)	15.00	45.00	30.00	5.00	5.00
Ability to make accurate interpretation and predictions	Frequency	2	9	7	1	1
	Percentage (%)	10.00	45.00	35.00	5.00	5.00
Eagerness to investigate after school	Frequency	2	9	7	1	1
	Percentage (%)	10.00	45.00	35.00	5.00	5.00
Eagerness to relate observations to theory work	Frequency	1	6	10	2	1
	Percentage (%)	5.00	30.00	50.00	10.00	5.00

The results presented in Table 4.5 indicate the ratings of students' abilities or characteristics related to various aspects of chemistry practical activities. From the findings, it was observed that the majority of students were rated to be weak or average in the Chemistry aspects outlined. With regard to making accurate observations, majority of the teachers 5(25%) and 7(35%) revealed that their students were weak and average respectively. An aggregate of 16 teachers corresponding to 80% also revealed that their students were either weak or average in doing investigations in Chemistry. Moreover, a total of 12(60%) teachers unanimously agreed that their students were either weak or average in using theory when doing investigations. Also, an aggregate of 15(75%) teachers revealed that their students were either weak or average in keeping neat and accurate records. Notwithstanding, a total of 16(80%) of the teachers demonstrated that their students were either weak or average in making accurate interpretation and predictions. The results also shows that the majority of teachers 16(80%) revealed that their students were either weak or average in the eagerness to investigate after school and the eagerness to relate observations to theory work.

The skills listed in Table 4.5 are crucial for the fundamental Chemistry process. Chemistry is taught through exposing students to the fundamental and integrated processes of science.

Students who study Chemistry perform practical activities to expand their knowledge and gain a better understanding of the world around them. It is therefore imperative that teachers or Chemistry instructors assist students develop all these skills while studying Chemistry so that practical exercises may help them to improve their performance.

4.3.5 Teacher Perspectives on the Impact of Practical Chemistry Activities in Senior High School

The respondents were asked to rate various effects of teaching and learning utilising Chemistry practical activities at the senior high school level. The following are some of the consequences studied: Pressure to cover the syllabus is an obstacle to Chemistry practical activities; pressure on teachers to ensure good grades is an obstacle to Chemistry practical activities; Chemistry practical activities increase good grade achievement; Chemistry practical activities reduce syllabus coverage; rather than being entertaining or motivating, Chemistry practical activities are drab (monotonous). Practical Chemistry activities are merely a drill and practice for passing examinations; Chemistry practical exercises are hampered by teachers' workload and a large number of students. The responses were rated using a Likert scale, and the findings are shown in Table 4.6.

Table 4.6: Teacher Perspectives on the Impact of Practical Chemistry Activities in Senior High School

Rating of the effects of Chemistry practical activities		**Disagree**	**Not Sure**	**Agree**
Chemistry practical activities increase understanding	Frequency	0	0	20
	Percentage (%)	0.00	0.00	100
Chemistry practical activities increase enjoyment	Frequency	0	5	15
	Percentage (%)	0.00	25.00	75.00
Pressure to cover syllabus is an obstacle to chemistry practical activities	Frequency	8	0	12
	Percentage (%)	40.00	0.00	60.00
Pressure on teachers to ensure good grades is an obstacle to chemistry practical activities	Frequency	0	0	20
	Percentage (%)	0.00	0.00	100
Chemistry practical activities increase achievement of good grades	Frequency	0	2	18
	Percentage (%)	0.00	10.00	90.00
Chemistry practical activities reduce syllabus coverage	Frequency	9	1	10
	Percentage (%)	45.00	5.00	50.00
Chemistry practical activities are monotonous and routine, rather than engaging or inspiring.	Frequency	20	0	0
	Percentage (%)	100	0.00	0.00
Chemistry practical activities are drills and practices only for passing examinations	Frequency	20	0	0
	Percentage (%)	100	0.00	0.00
Teachers' work load is an obstacle to chemistry practical activities	Frequency	16	2	2
	Percentage (%)	80	10.00	10.00
Large numbers of students are an obstacle to chemistry practical activities	Frequency	8	0	12
	Percentage (%)	40.00	0.00	60.00

The results presented in Table 4.6 shows the findings of some of the effects of chemistry practical activities on learning and teaching of Chemistry in senior high school. The findings show that all the respondents 20(100%) agreed that chemistry practical activities increase understanding while 18(90%) agreed that chemistry practical activities increase achievement of good grades.

Furthermore, all the respondents 20(100%) disagreed that chemistry practical activities are monotonous and routine, rather than engaging or inspiring. This implies that most students find chemistry practical activities exciting a fact which teachers can exploit to plan and increase the frequency of chemistry practical activities. On whether chemistry practical activities increase enjoyment, a majority 15(75 %) agreed. The findings on whether pressure to cover syllabus is an obstacle to chemistry practical activities, 10(50%) agreed, 9(45%) disagreed while 1(5%) was not sure. On whether pressure on teachers to ensure good grades in chemistry is an obstacle to chemistry practical activities, 18(90%) of respondents agreed while 2(10%) were not sure. For the observation that chemistry practical activities reduce syllabus coverage, a majority of chemistry teachers agreed.

On whether chemistry practical activities are drills and a practice only for passing examinations, all the respondents 20(100%) disagreed and on the issue of whether teachers' work load is an obstacle to chemistry practical activities 16(80%) disagreed, 2(10%) were not sure and 2(10%) agreed. Finally, on whether large number of students is an obstacle to chemistry practical activities, 8(40%) of the respondents disagreed while 12(60%) of the teachers agreed.

4.3.6 Types of Chemistry Practical Activities

The research looks into the various methods for carrying out chemistry practical activities. These are both demonstration and classroom experiments. Demonstration experiments are ones that the teacher does while the students watch. The demonstration can take place in the laboratory, in the classroom or outside. The teacher gives a demonstration using either purchased or homemade equipment (improvised equipment). Demonstrations can be done with or without student participation, and they are used to illustrate concepts and encourage inquiry. Class experiments are ones in which the students themselves carry out the practical activities, make observations, and document them. Learners in this category undertake chemistry practical activities as individuals or in groups, using the provided apparatus, and are instructed by the teacher or a worksheet on what to do. The respondents were asked to estimate how often each of the different types of chemical practical activities was used during the teaching and learning of Chemistry in the study. The findings are presented in Table 4.7.

Table 4.7: Usage of Demonstration and Class Experiment Types of Lessons (N = 20)

Usage of types of chemistry practical activities		**Never**	**Occasionally**	**Frequently**	**Very frequently**
Demonstration experiment	N	0	0	15	5
	%	0.00	0.00	75.00	25.00
Class Experiment	N	3	8	7	2
	%	15.00	40.00	35.00	10.00

The results in Table 4.7 shows the findings of how frequently each of the two types of Chemistry practical activities was adopted during the teaching and learning of

Chemistry in the study area. The findings indicate that most respondents 15(75%) frequently adopted demonstration experiment type of practical activity. On class experiment type of practical activity, 3(15%) respondents indicated that they never adopt it in the teaching of Chemistry, 8(40%) of the respondents revealed that they occasionally use it while 7(37%) indicated that they frequently used it. However, only two respondents, 2(10%) revealed that they adopt the class experiment very frequently. The results from table 4.7 indicates that the chemistry teacher in the study area mostly use demonstration experiment in teaching chemistry practical.

4.4 Research Question 2: What is the effect of practical activities in Chemistry on students' performance in Chemistry in the study area?

This research question sought to determine the effect of practical activities in Chemistry on students' achievements or performance. The study tested the hypothesis that there is no statistically significant difference in performance in Chemistry of students exposed to various types of Chemistry practical activities and when they were not exposed to Chemistry practical activities. The descriptive statistics of the pre-test and post-test scores are presented in Table 4.8.

Table 4.8: Descriptive Statistics of Pre-test Scores and Post-test Scores (N=50)

Chemistry Assessment	**N**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Pre-test scores	50	8	13	51.73	12.304
Post-test scores	50	11	18	64.80	14.742

Table 4.8 presents the descriptive statistics of the participants in the pre-test and post-test assessment. The mean pre-test scores and the standard deviation calculated were (M = 51.73, SD = 12.304); its minimum and maximum values were 8 and 13

respectively. More so, the mean post-test scores and its standard deviation computed was (M = 64.80, SD = 14.742). Also, the minimum and maximum post-test scores were 11 and 18 respectively. These results suggest that there was an improvement in students' performance after the implementation of the intervention. Hence, the results suggest that the practical activities had positive effect on students' performance in the study of Chemistry.

The study sought to determine the effect of types of chemistry practical activities on students' performance in senior high school. Table 4.9 shows the results of the analysis.

Table 4.9: Analysis on Effect of Types and Quantity of Chemistry Practical Activities on Post -Test Scores

Coefficients

Model	**Standardised Coefficients**	**T**	**Sig.**
(Constant)		18.552	0.000
Class experiment lesson	0.319	21.766	0.000
teacher demonstrations lesson	0.073	1.845	0.000

The dependent variable, independent variables, standardised coefficients, T-value, and significance of the two types of Chemistry practical activities are listed in Table 4.8. On chemistry lessons involving student chemistry practical activities, that are using class experiment, the Table 4.8 indicates a T-value of 21.766 which is statistically significant at 0.000 which is less than 0.05. The null hypothesis is therefore rejected, implying that the student chemistry practical activities that is, class experiments significantly predict the post-test scores. Finally, on chemistry lessons involving teacher demonstrations, the table indicates a T-value of 1.845 which is statistically significant at 0.000 and less than 0.05. The null hypothesis is therefore rejected. This means that teacher's demonstration has a strong correlation with the post-test scores. As a result, the different types of Chemistry practical lessons (class experiment and teacher demonstration) have an important role in deciding students' performance.

Table 4.10: ANOVA Analysis on Effect of Types and Quantity of Chemistry Practical Activities on Post -Test Scores

ANOVA	Sum of Squares	DF	Mean Square	F	Sig.
Regression	74.7456	2	16.7424	85.234	0.00

Table 4.10 displays the results of the ANOVA analysis for the influence of exposure to various types of Chemistry practical activities. This study examines the premise that there was no significant difference in Chemistry performance between students who were exposed to various types of Chemistry practical activities and when they were not exposed to the practical activities. The null hypothesis is rejected due to an F-Statistic 85.234 and a significance threshold of $0.000 < 0.05$, and we infer that the exposure to the types of Chemistry practical activities has a statistically significant effect on students' performance. The foregoing findings suggest that there is still some practical activities to be done in order to master the basic skills such as observation, measurement and accurate recording of experiment findings as well as investigative abilities such as analysis and making inferences. Teachers must know which practical work applies to which concept while choosing the forms of practical activity. It also implies that teachers should have a tacit understanding of how to perform the practical activities. When teaching Chemistry instructors, pre-service and in-service teacher education institutes should instill practical skills, confidence and good attitude toward

practical work.

These revelations from the study are in-line with the study conducted by Horner, Miller, Steed, and Sutcliffe (2016) that different strategies of chemistry practical activities exists for teachers of chemistry to adopt to help students make links between two domains of knowledge: the domain of objects and observable properties and events on the one hand, and the domain of ideas on the other. In furtherance, the place of experimental work in laboratories has always assumed a high profile at all levels of chemical education (Irwansyah, Slamet, & Ramdhani, 2018). The modern laboratory provides students opportunities to learn specific procedures and instrumentation and to develop skills such as problem-solving and communication (Geleta, 2018).

4.5 Research Question 3: What is the impact of the quality of Chemistry practical activities on Senior High School students' performance in the study area?

The purpose of this research question was to see how the quality of Chemistry practical activities affected students' performance in senior high school. To reach this goal, the researcher investigated the hypothesis that there is no statistically significant difference in Chemistry performance between students who were exposed to various qualities of Chemistry practical activities and when they were not exposed to the practical activities in the study.

4.5.1 Chemistry Practical Activities: Types and Quantities

The goal of the study was to determine the types and quantities of Chemistry practical activities used in teaching and learning Chemistry. As a result, the study looked at how respondents ranked the quantity of different types of Chemistry practical activities in terms of percentage of time spent during Chemistry teaching and learning. This was done to see what percentage of Chemistry lessons were made up of each of the following Chemistry practical activities: Chemistry lessons, Chemistry practical activities, students Chemistry practical activities, and teacher demonstrations. The respondents were asked to estimate how much of their learning time was spent on Chemistry practical activities, and their responses were graded on a Likert scale. The results are presented in Table 4.11.

Table 4.11: Perspectives of Students on the Types and Quantity of Chemistry Practical Activities (N = 50)

Perspectives of Students on the Types and Quantity of Chemistry Practical Activities		**No time**	**A little time**	**Half the time**	**Most of the time**	**All the time**
Chemistry lessons is student practical activities	Frequency	0	8	10	11	21
	Percent	0	16.00	20.00	22.00	42.00
Chemistry lessons is teacher demonstrations	Frequency	5	9	14	16	6
	Percent	10.00	18.00	28.00	32.00	12.00

The results in Table 4.11 show the findings on quantity and types of Chemistry practical activities employed in the teaching and learning of chemistry in senior high schools in the study area. The findings indicate that Chemistry teaching and learning employed practical activities in most of the lessons as shown in Table 4.11. Eight (8) (16%) of the students revealed that they had a little practical activity, 10 (20%) half of the time, 11 (22%) had it most of the time while 21 (42%) had practical activities all the time. 5(10%) indicates that no time was allocated to Chemistry lesson by demonstration. However, 9 (18%) had it a little of the time, 14 (28%) half of the time, 16 (32%) had it most of the time and 6 (12%) had it all the time.

The data suggests that no time is ever spent teaching Chemistry without students participating in practical activities (0.00 %). This is unusual, especially in the light of senior high school timetables and laboratory facilities.

4.5.2 Adequacy of Chemistry Teaching and Learning Materials

Students and Chemistry teachers participated in the study to assess the appropriateness of Chemistry teaching and learning materials in senior high schools in the study area. Appropriate Chemistry laboratories, adequate Chemistry apparatus and reagents; adequate relevant Chemistry textbooks; adequate qualified Chemistry teachers; adequate time for teaching Chemistry; and adequate time for Chemistry practical activities are among the factors considered. A three-point Likert scale was used to evaluate the responses. The results are presented in Table 4.12.

Table 4.12: Adequacy of Teaching and Learning Resources in the School (N = 70)

Teaching and Learning Resources in the School		Disagree	Not Sure	Agree
Adequate chemistry Laboratory/s (Space & equipment)	Frequency	45	10	15
	Percentage (%)	64.29	14.29	21.42
Adequate chemistry apparatus & reagents	Frequency	50	0	20
	Percentage (%)	71.43	0.00	28.57
Adequate relevant chemistry textbooks	Frequency	35	5	30
	Percentage (%)	50.00	7.14	42.86
Adequate chemistry teachers	Frequency	15	0	55
	Percentage (%)	21.42	0.00	78.58
Adequate Time for teaching chemistry	Frequency	25	20	25
	Percentage (%)	35.71	28.58	35.71
Adequate Time for chemistry practical activities	Frequency	20	20	30
	Percentage (%)	28.58	28.58	42.84

The results contained in Table 4.12 show the findings on the adequacy of chemistry teaching and learning resources in senior high schools in the study area. The findings indicate that chemistry teaching and learning resources in senior high schools are not adequate. 45 (64.29%) of the respondents disagreed that they have adequate chemistry laboratory/s (Space and equipment); 10 (14.29%) of the respondents were not sure whether they have adequate chemistry laboratory or not while 15 (21.42%) of the respondents agreed that they have adequate chemistry laboratory.

More so, 50 (71.43%) of the respondents disagreed that they have adequate chemistry apparatus and reagents while 20 (28.57%) agreed. Also, 35 (50%) of the respondents disagreed that they have adequate relevant chemistry textbooks; 5 respondents corresponding to 7.14% were not sure as to whether they have adequate relevant chemistry textbooks for their lessons; 30 (42.86%) respondents however agreed that they have relevant chemistry textbooks. With regard to adequate qualified chemistry teachers, 15 (21.42%) of the respondents disagreed while 55 (78.58%) of the participants agreed that they have adequate qualified chemistry teachers. In addition, 25 (35.71%) of the participants disagreed that they have adequate time for teaching and learning chemistry, 20 (28.58%) of the respondents were not sure while another 25 (35.71%) agreed. Also, 20 (28.58%) of the respondents disagreed that they have adequate time for chemistry practical activities, another 20 (28.58%) were not sure while 30 (24.84%) agreed that they have adequate time for chemistry practical activities. These findings suggest that the senior high schools in the study area were not adequately equipped for chemistry practical activities.

In addition, to achieve the third objective, the study tested the hypothesis that there is no significant difference in performance in chemistry of students exposed to different qualities of chemistry practical activities and when they were not exposed to practical activities in the study and also explored factors which correlate with the quality of chemistry practical activities undertaken in senior high schools in the study area. The study used ANCOVA analysis to show the effect of quantity and types of chemistry practical lessons in senior high schools on performance. The results are presented in Table 4.13.

Table 4.13: ANCOVA Analysis of the impact of quality of Chemistry practical activities on Senior High School students' performance

Tests of Between-Subjects Effects

Dependent Variable: Post Test

Source	**Type III Sum of Squares**	**DF**	**Mean Square**	**F**	**Sig.**
Corrected Model	57.886	2	16.629	0.667	0.426
Intercept	5727.721	1	6728.423	411.384	0.000
Student chemistry practical activities percentage	3.534	1	3.535	14.86	0.000
Teacher demonstrations percentage	0.817	1	0.819	5.56	0.003
Error	13309.416	731	21.844		
Total	**163241.000**	**735**			

As can be observed from the related significance level, the first covariate, student chemistry practical activities (class experiment lessons) has an F-statistic (14.86) which is statistically significant with a p-value of 0.000. As can be observed from its related significance level, the second covariate, percentage of teacher demonstrations in chemistry lessons, has an F statistic of 5.56 which is statistically significant at a p-value of 0.003. The results show that as the values of the covariates rise, the values of the dependent variable, post-test, rise as well. The third research question which aimed at investigating the impact of the quality of chemistry practical activities on students' performance in senior high schools in the study area was answered because the results show a linear relationship between covariates and the dependent variable, the post-test.

4.6 Discussion of Results

The findings of the study are discussed under the following sub-headings:

4.6.1 Research Question one: The impact of the nature of Chemistry practical activities on Senior High School students' performance in the study area.

The findings from the study on students’ level of discipline revealed that 12 (60%) of the teachers were of the view that their students were disciplined, moreover, 6(30%) teachers indicated that their students were very disciplined. Only 2 (10%) teachers indicated that they were not sure as to whether their students were disciplined. However, as far as undisciplined and very undisciplined were concerned, no participants selected them. Moreover, on rating of students’ academic abilities, the findings indicate that majority of students were above average (High) in academic ability 10 (50%). As far as academic ability in sciences was concerned, majority of the teachers 8(40%) indicated that their students were average. On students’ academic ability in chemistry, 6 (30%) teachers revealed that their students were average. Also, regarding ability in chemistry practical activities, 7 (35%) of the teachers indicated that their students were average.

Meanwhile, on students’ attitude towards practical activities in chemistry, majority of the teachers revealed that students showed poor attitude in: chemistry subject 10 (50%); chemistry assignment 9 (45%); chemistry practical activities 7(35%); and chemistry theory lessons 8 (40%), while 10(50%) of the teachers agreed that the students showed poor attitude towards science subject.

More so, on teachers' rating of students' chemistry practical activities, the findings indicated that the majority of students were rated to be weak or average in the Chemistry aspects outlined. With regard to making accurate observations, majority of the teachers 5 (25%) and 7 (35%) revealed that their students were weak and average respectively. An aggregate of 16 teachers corresponding to 80% also revealed that their students were either weak or average in doing investigations in Chemistry. Moreover, a total of 12 (60%) teachers unanimously agreed that their students were either weak or average in using theory when doing investigations. Also, an aggregate of 15 (75%) teachers revealed that their students were either weak or average in keeping neat and accurate records. Notwithstanding, a total of 16 (80%) of the teachers demonstrated that their students were either weak or average in making accurate interpretations and predictions. The results also show that the majority of teachers 16 (80%) revealed that their students were either weak or average in the eagerness to investigate after school and the eagerness to relate observations to theory work.

In addition, on teacher perspective on the impact of practical chemistry activities in senior high school, the findings show that all the respondents 20 (100%) agreed that chemistry practical activities increase understanding while 18 (90%) agreed that chemistry practical activities increase achievement of good grades.

Furthermore, all the respondents 20 (100%) disagreed that chemistry practical activities are monotonous and routine, rather than engaging or inspiring. This implies that most students find chemistry practical activities exciting a fact which teachers can exploit to plan and increase the frequency of chemistry practical activities. On whether chemistry practical activities increase enjoyment, a majority 15 (75 %) agreed. The findings on whether pressure to cover syllabus is an obstacle to chemistry practical activities, 10 (50%) agreed, 9 (45%) disagreed while 1 (5%) was not sure. On whether pressure on teachers to ensure good grades in chemistry is an obstacle to chemistry practical activities, 18 (90%) of respondents agreed while 2 (10%) were not sure. For the observation that chemistry practical activities reduce syllabus coverage, a majority of chemistry teachers agreed.

On whether chemistry practical activities are drills and a practice only for passing examinations, all the respondents 20 (100%) disagreed and on the issue of whether teachers' work load is an obstacle to chemistry practical activities 16 (80%) disagreed, 2 (10%) were not sure and 2 (10%) agreed. On whether large number of students is an obstacle to chemistry practical activities, 8 (40%) of the respondents disagreed while 12 (60%) of the teachers agreed.

Finally, on the types of chemistry practical activities, the findings indicate that most respondents 15 (75%) indicated that they frequently adopted demonstration experiment type of practical activity. On class experiment type of practical activity, 3 (15%) respondents indicated that they never adopt it in the teaching of Chemistry, 8 (40%) of the respondents revealed that they occasionally use it while 7 (37%) indicated that they frequently used it. However, only two respondents, 2 (10%) revealed that they adopt the class experiment very frequently. The revelations from the study are in agreement with the study conducted by Abdillah, Linuwih, and Isnaeni (2017) and Farkhanda and Muhammad (2020) that practical work is essential to teaching and learning in the field of scientific studies and that good quality practical work helps develop students' understanding of scientific processes and concepts. The findings from the study are in agreement with the works of Linda, Sulistya, and Putra (2018) who espoused that students should be exposed to chemistry practical activities such as teacher demostration and classroom experiments. These activities will enable students to define the work's key objectives and plan and execute the desired task, as well as identifies the conceptual and practical challenges, document them and discusses the outcomes and observations, and make practical adjustments and improvements (Linda, Sulistya, & Putra, 2018).

4.6.2 Research Question two: The effect of practical work in Chemistry on students' performance in Chemistry in the study area.

The mean pre-test scores and the standard deviation calculated were (M = 51.73, SD = 12.304); its minimum and maximum values were 8 and 13 respectively. More so, the mean post-test scores and its standard deviation computed was (M = 64.80, SD = 14.742). Also, the minimum and maximum post-test scores were 11 and 18 respectively. These results suggest that there was an improvement in students' performance after the implementation of the intervention. Moreover, the results suggest that the practical activities had positive effect on students' performance in the study of Chemistry.

On chemistry lessons involving student chemistry practical activities, which were using class experiment, the findings in the Table 4.7 revealed a T-value of 21.766 which is statistically significant at 0.000 which is less than 0.05. The null hypothesis was therefore rejected, implying that the student chemistry practical activities that is, class experiments significantly predict the post-test scores. Finally, on chemistry lessons involving teacher demonstrations, the table indicates a T-value of 1.845 which is statistically significant at 0.000 and less than 0.05. The null hypothesis is therefore rejected. This means that teacher's demonstration has a strong correlation with the post-test scores. As a result, the different types of Chemistry practical lessons (class experiment and teacher demonstration) have an important role in deciding students' performance.

4.6.3 Research Question three: The impact of the quality of Chemistry practical activities on Senior High School students' performance in the study area

On chemistry practical activities: types and quantities, the findings indicate that Chemistry teaching and learning employed practical activities in most of the lessons as shown in Table 4.9. 8 (16%) students reveal that they had a little practical activity, 10 (20%) half of the time, 11 (22%) had it most of the time while 21 (42%) had practical activities all the time. Moreover, 5 (10%) indicates that no time was allocated to Chemistry lesson by demonstration. However, 9 (18%) had it a little of the time, 14 (28%) half of the time, 16 (32%) had it most of the time and 6 (12%) had it all the time.

On adequacy of chemistry teaching and learning materials, the findings indicate that chemistry teaching and learning resources in senior high schools are not adequate. 45 (64.29%) of the respondents disagreed that they have adequate chemistry laboratory/s (Space & equipment); 10 (14.29%) of the respondents were not sure whether they have adequate chemistry laboratory or not while 15 (21.42%) of the respondents agreed that they have adequate chemistry laboratory.

More-so, 50 (71.43%) of the respondents disagreed that they have adequate chemistry apparatus and reagents while 20 (28.57%) agreed. Also, 35 (50%) of the respondents disagreed that they have adequate relevant chemistry textbooks; 5 respondents corresponding to 7.14% were not sure as to whether they have adequate relevant chemistry textbooks for their lessons; 30 (42.86%) respondents however agreed that they have relevant chemistry textbooks. With regard to adequate qualified chemistry teachers, 15 (21.42%) of the respondents disagreed while 55 (78.58%) of the participants agreed that they have adequate qualified chemistry teachers. In addition, 25 (35.71%) of the participants disagreed that they have adequate time for teaching and learning chemistry, 20 (28.58%) of the respondents were not sure while another 25 (35.71%) agreed. Also, 20 (28.58%) of the respondents disagreed that they have adequate time for chemistry practical activities, another 20 (28.58%) were not sure while 30 (24.84%) agreed that they have adequate time for chemistry practical activities.

Meanwhile**,** the related significance level, the first covariate which was student chemistry practical activities (class experiment lessons) had an F-statistic (14.86) which was statistically significant with a p-value of 0.000. The second covariate which was the percentage of teacher demonstrations in chemistry lessons has an F statistic of 5.56 which was statistically significant at a p-value of 0.0003. The results show that as the values of the covariates rise, the values of the dependent variable, post-test, rise as well. The findings are in agreement with the study conducted by Farida, Helsy, Fitriani, & Ramdhani (2018) as they indicated that adequate science teaching and learning resources should be provided to students to harness, sustain and arouse students' analytical and critical thinking skills as well as a passion for the science. Instructional materials, types of chemistry practical activities and the frequency of chemistry practical activities have a significant influence in the performance of chemistry at the senior high school level (Tettey-Wayo, 2018). When students only carry out chemistry practical instructions from worksheets to complete a practical activity, they are limited in the ways they can contribute. As a result, students fail to perceive the conceptual and procedural understandings that were the teachers' intended goals for the laboratory activities (Gudyanga & Jita, 2019; Russell & Weaver, 2011; Sandi-Urena et al., 2011).

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Overview

The findings of the study are summarised in this chapter, together with conclusions and recommendations for improving senior high school teaching of chemistry in the study area.

5.2 Summary of the Study

The study found the mean pre-test scores and the standard deviation of participants to be (M = 51.73, SD = 12.304), the minimum and maximum values were 8 and 13 respectively. More so, the mean post-test scores and its standard deviation computed were (M = 64.80, SD = 14.742). The minimum and maximum post-test scores were 11 and 18 respectively implying that chemistry practical activities had a positive effect on students' performance in chemistry. This shows that the use of chemistry practical activities had a significant improvement in the performance of chemistry at the senior high schools in the study area and so it is a better method of teaching and learning chemistry. The study found an F-statistic (14.86) which is statistically significant with a p-value of 0.000. As can be observed from its related significance level, the second covariate, percentage of teacher demonstrations in chemistry lessons, has an F statistic of 5.56 which is statistically significant at a p-value of 0.0003. The results show that as the values of the covariates rise, the values of the dependent variable, post-test, rise as well.

The study found that there is a linear relationship between various types of practical activities and learners' performance in chemistry. The ANCOVA analysis indicated that the values of the dependent variable, post-test, increases as the values of the covariates, types of chemistry practical activities increase. For example, the findings showed that, demonstration experiment and discussion type of practical activity had F-statistic of 14.86 and an associated significance level of 0.000, indicating a significant linear relationship with the dependent variable which is the post- test. This implies that the teaching and learning of chemistry in senior high schools in the study area is improved and performance improves when different types of chemistry practical activities (classroom experiments and teacher demonstrations) are used.

In addition, the majority of senior high school students have a favourable attitude toward chemistry and chemistry practical activities, according to the study. This research indicates that senior high school students have a positive attitude toward chemistry practical activities. The findings imply that teachers should be more conscious of students' positive attitudes toward chemistry practical activities, rather than viewing students' attitudes as negative and unchangeable. Teachers should take into account the topic being studied and create a more favourable learning atmosphere in the classroom.

5.3 Conclusions

The data show that using chemistry practical activities to improve students' chemistry performance in senior high schools in the study area is an effective strategy. The study also shows that the nature, quality, and frequency of chemistry practical activities in teaching and learning of chemistry improve students' performance. Using chemistry practical activities improves students' knowledge and understanding when compared to not using chemistry practical activities at all.

While it is crucial to encourage the use of chemistry practical activities in the teaching and learning of chemistry, the nature, quality and frequency of practical activity must also be considered. Exposure to various forms of chemistry practical activities had a considerable positive effect on students' performance, according to the study. Chemistry practical work has a number of advantages for students. Students' enthusiasm and ability in science courses, as well as their achievement in science, are increased through chemistry practical activities. This is because chemistry practical sessions assist students in comprehending complex or abstract theories and chemical principles.

Furthermore, chemistry practical activities must provide students with a variety of benefits, including the development of scientific thinking and enthusiasm for chemistry, the development of basic manipulative and problem-solving skills, hands-on experiences in using instruments and apparatus, and the identification of chemical hazards and safe chemical handling, as well as other science process skills.

5.4 Recommendation of the Study

The study suggests the following based on its findings:

- Teaching and learning of chemistry in the study area should include more practical work. In order to improve their practices, chemistry teachers must receive rigorous in-service training in practical work management and current research.
- Teachers' pre-service training should include extensive practice in fundamental and higher-order science process abilities so that new teachers are more confident in their ability to use practical work while teaching chemistry and other science concepts.

- Furthermore, teachers in the study area should also be taught how to utilise hand tools so that they can improvise science equipment for practical work as necessary. The number of students in chemistry classroom needs to be lowered in order to increase the quality of practical chemistry activities. This could be accomplished by dividing large course into several smaller ones. This necessitates the hiring of more chemistry teachers, as well as the construction and equipping of extra classrooms and laboratories all of which can be addressed by the ministry of education.
- It is recommended that students be provided the opportunity to engage to do in-depth studies in order for chemistry practical activities to have a major positive impact on their ability to master both the desired practical abilities and the underlying theory. In-depth or deep studies allows students to define the work's key objectives and plan and execute them, as well as identify the conceptual and practical obstacles students face, document and discuss findings and observations, and offer practical changes and improvement.

5.5 Suggestions

- It is recommended that the curriculum and learning requirements for chemistry practical activities in senior high school chemistry be examined further, as well as an in-depth examination of teacher competence in the teaching of practical chemistry.
- It is critical to consider reducing the number of students in chemistry classrooms in order to increase the quality of practical chemistry activities. This will necessitate the hiring of more chemistry teachers, as well as the construction and equipping of extra classroom and laboratories. The activities and exercises in the classroom should be planned in such a way that they

encourage students to make connections between the practical and theoretical. Discussing and pondering on the connections between the natural world and chemistry theories should be given sufficient time and attention.

REFERENCES

Abdillah, C., Linuwih, S., & Isnaeni, W. (2017). The effectiveness of model learning Preser-X assisted LKS against science process skills and understanding students concept. *Journal of Primary Education*, *6*(3), 192-199.

Abdurrahman, M. S., & Madugu, A. (2014). Interrelationship between Students' Performance in Mathematics and Physics in Senior Secondary Schools of Birnin-Kebbi Local Government Area Of Kebbi State. *International Journal of Scientific & Engineering Research*, *5*(11), 1494-1507.

Abrahams, I., & Millar, R. (2008). Does practical work really work? A study of the effectiveness of practical work as a teaching and learning method in school science. *International journal of science education*, *30*(14), 1945-1969.

Abrahams, I., Reiss, M. J., & Sharpe, R. (2014). The impact of the 'Getting Practical: Improving Practical Work in Science'continuing professional development programme on teachers' ideas and practice in science practical work. *Research in Science & Technological Education*, *32*(3), 263-280.

Achor, E. E., Kurumeh, S., & Orokpo, C. (2012). Gender dimension in predictors of students' performance in MOCK-SSCE practical and theory chemistry examinations in some secondary schools in Nigeria. *Education*, 2(2), 16-22.

Adom, D., Yeboah, A., & Ankrah, A. K. (2016). Constructivism philosophical paradigm: Implication for research, teaching and learning. *Global Journal of Arts Humanities and Social Sciences*, *4*(10), 1-9.

Adu-Gyamfi, K., & Ampiah, J. G. (2016). The Junior High School Integrated Science: The Actual Teaching Process in the Perspective of an Ethnographer. *European Journal of Science and Mathematics Education*, *4*(2), 268-282.

Aina, J. K., & Adedo, G. A. (2013). Perceived causes of students' low enrolment in science in secondary schools, Nigeria. *International Journal of secondary education*, *1*(5), 18-22.

Alabi, O. A. (2014). Effect of activity based teaching strategy on students' achievement on secondary school students in Chemistry. *Journal of Education and Policy review*, *6*(2), 119-128.

Alhammad, K. (2015). A conceptual framework for re-shaping science education in Saudi Arabia. In Science education in the Arab gulf states . *Brill Sense*, 121-136.

Amponsah, I. V., Addo-Mensah, D., Anokye, M., Babah, R., & Etsiwah, I. (2019). The effect of practical work and motivation on students' desire to study stem subjects. *International Conference on Education and New Learning Technologies*, 990-999.

Anaso, J. N. (2017). chemistry laboratory equipment and senior school students'performance in north west nigeria: implications for counseling. *Journal Of Curriculum And Instruction*, *10*(2), 15-23.

Awad, B. (2014). Empowerment of teaching and learning chemistry through information and communication technologies. *African Journal of Chemical Education*, *4*(3), 34-47.

Aydoğdu, C. (2015). Science and Technology Teachers' Views About the Causes of Laboratory Accidents. *International Journal of Progressive Education*, *11*(3).

Azure, J. A. (2015). Senior High School students' views on the teaching of Integrated Science in Ghana. *Journal of Science Education and Research*, *1*(2), 49-61.

Barua, L., Zou, B., & Zhou, Y. (2020). Machine learning for international freight transportation management: a comprehensive review. *Research in Transportation Business & Management*, *34*, 100-120.

Basheer, A., Hugerat, M., Kortam, N., & Hofstein, A. (2016). The effectiveness of teachers' use of demonstrations for enhancing students' understanding of and attitudes to learning the oxidation-reduction concept. *Eurasia Journal of Mathematics,Science and Technology Education*, *13*(3), 555 - 570.

Bellou, I., Papachristos, N. M., & Mikropoulos, T. A. (2018). Digital learning technologies in chemistry education: A review. *Digital Technologies Sustainable Innovations for Improving Teaching and Learning*, 57-80.

Bete, A. O. (2020). Students' knowledge and process skills in learning grade-8 chemistry. *Journal of Research Policy & Practice of Teachers and Teacher Education*, *10*(1), 1-13.

Biesta, G. (2017). Mixing methods in educational research. *Research methods and methodologies in education*, 159-165.

Blonder, R., Rap, S., Mamlok-Naaman, R., & Hofstein, A. (2015). Questioning behavior of students in the inquiry chemistry laboratory: Differences between sectors and genders in the Israeli context. *International Journal of Science and Mathematics Education*, *13*(4), 705-732.

Boukoberine, M. N., Zhou, Z., & Benbouzid, M. (2019). A critical review on unmanned aerial vehicles power supply and energy management: Solutions, strategies, and prospects. *Applied Energy*, *25*, 113- 122.

Cahyana, U., Paristiowati, M., Savitri, D. A., & Hasyrin, S. N. (2017). Developing and application of mobile game based learning (M-GBL) for high school students performance in chemistry. *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(10), 7037 - 7047.

Chen, B., & Chen, L. (2021). Examining the sources of high school chemistry teachers' practical knowledge of teaching with practical work: from the teachers' perspective. *Chemistry Education Research and Practice*, *22*(2), 476-485.

Chen, T. L., Kim, H., Pan, S. Y., Tseng, P. C., Lin, Y. P., & Chiang, P. C. (2020). Implementation of green chemistry principles in circular economy system towards sustainable development goals: Challenges and perspectives. *Science of the Total Environment*, *716*, 136998.

Chen, X., & Eilks, I. (2019). An Analysis of the Representation of Practical Work in Secondary Chemistry Textbooks from Different Chinese Communities. *Science Education International*, *30*(4), 354-363.

Clark, J., Porath, S., Thiele, S., & Jobe, M. (2020) Action Research *NPP.eBook.34*

Collins, T. J. (2017). Review of the twenty-three year evolution of the first university course in green chemistry: teaching future leaders how to create sustainable societies. *Journal of Cleaner Production*, *140*, 93-110.

Cruz, A. V., Madden, P. E., & Asante, C. K. (2018). Toward cross-cultural curriculum development: An analysis of science education in the Philippines, Ghana, and the United States. *In Intercultural studies of curriculum* , 37-57.

Dey, S., Dhal, G. C., Mohan, D., & Prasad, R. (2019). Application of hopcalite catalyst for controlling carbon monoxide emission at cold-start emission conditions. *Journal of Traffic and Transportation Engineering (English Edition)*, 6(5), 419-440.

Doe, H. (2015). I*mproving teaching and learning of integrated science practicals in selected Senior High Schools* (Doctoral dissertation, University of Education, Winneba). University of Education, Winneba Press, 23-35.

Donkor, A. K., & Justice, D. K. (2016). Girls education in science: The challenges in northern Ghana. *Education & Social Policy*, *3*(1), 45-59.

Eizenberg, E., & Jabareen, Y. (2017). Social sustainability: A new conceptual framework. *Sustainability*, *9*(1), 68-75.

Erinosho, S. Y. (2013). How do students perceive the difficulty of physics in secondary school? An exploratory study in Nigeria. *International Journal for Cross-Disciplinary Subjects in Education*, *3*(3), 1510-1515.

Essibu, J. K. (2018). A Comparative Analysis of the Performance of Regular Senior High Science Student and Remedial Science Student in Ghana. *Academy of Educational Leadership Journal*, *22*(2), 1-9.

Farida, I. C., Helsy, I., Fitriani, I., & Ramdhani, M. A,. (2018) Learning Material of Chemistry in High School Using Multiple Representations. *IOP Conference Series: Material Science and Engineering. 288.*

Farkhanda, J., & Muhammad, T. A. (2020). Effect of Simulated Chemistry Practicals on Students'Performance at Secondary School Level. *Journal of Education and Educational Development*, *7*(1), 119-139.

Fung, F. M. (2015). Using first-person perspective filming techniques for a chemistry laboratory demonstration to facilitate a flipped pre-lab. *Journal of Chemical Education*, *92*(9), 1518-1521.

Geleta, T. K. (2018). The upshot of availability and utilization of Science laboratory inputs on students' academic achievement in high school Biology, Chemistry and Physics in Ilu Abba Bora Zone, Southwestern Ethiopia. *International Journal of Scientific and Research Publications*, *8*(9), 298- 307.

Ghana Statistical Service. (2010). *2010 Population and Housing Census: District Analytical Report- Sekondi-Takoradi Metropolitan.* Accra: Ghana Statistical Service.

Ghani, I. A., Ibrahim, N. H., Yahaya, N. A., & Surif, J. (2017). Enhancing students' HOTS in laboratory educational activity by using concept map as an alternative assessment tool. *Chemistry education research and practice*, *18*(4), 849-874.

Gudyanga, R., & Jita, L. C. (2019). Teachers' implementation of laboratory practicals in the South African physical sciences curriculum. *Issues in Educational Research*, *29*(3), 715-731.

Hanson, R. (2017). Enhancing students 'performance in organic chemistry through context-based learning and micro activities-a case study. *European Journal of Research and Reflection in Educational Sciences*, *5*(6), 7-20.

Harshman, J., & Yezierski, E. (2017). Assessment data-driven inquiry: A review of how to use assessment results to inform chemistry teaching. *Science Educator*, *25*(2), 97-107.

Haruna, T. Z., Salifu, A., & Mabee, M. K. (2018). Difficulties Colleges of Education Students face in chemistry practical in Northern Region of Ghana. *ADRRI Journal of Physical and Natural Sciences*, *2*(3), 1-31.

Hennink, M., Hutter, I., & Bailey, A. (2020). *Qualitative research methods.* Sage.

Hofstein, A. (2015). The development of high-order learning skills in high school chemistry laboratory:'Skills for Life'. *Chemistry Education*, 25-33.

Horner, K. E., Miller, M. A., Steed, J. W., & Sutcliffe, P. M. (2016). Knot theory in modern chemistry. *Chemical Society Reviews*, *45*(23), 6432-6448.

Irwansyah, F. S., Slamet, C., & Ramdhani, M. A. (2018). The analysis of determinant factors in selecting laboratory equipment in chemistry education experiment. *Chemical Engineering Transaction*, *63*, 793-798.

Issah, S. E. (2016). *Using practical work to improve students' attitude and performance in integrated science_ a case study of Lawra senior high school (Doctoral dissertation, University of Education, Winneba).* Winneba, Ghana: University of Education, Winneba Press.

Jaakkola, E. (2020). Designing conceptual articles: four approaches. *AMS review*, *10*(1), 18-26.

Jabeen, F., & Afzal, M. T. (2020). Effect of simulated chemistry practicals on students' performance at secondary school level. *Journal of Education and Educational Development*, *7*(1), 119-139.

Kinyota, M. (2020). The status of and challenges facing secondary science teaching in Tanzania: a focus on inquiry-based science teaching and the nature of science. *International Journal of Science Education*, *42*(13), 2126-2144.

Koirala, K. P. (2019). Effectiveness of Practical Work on Students' Achievement in Science at Secondary Level in Gorkha District Nepal. *Journal of Advances in Education Research*, *4*(4), 139–147.

Koki, A. T. (2019). *Effect of Chemistry Practicals on Student's Performance in Chemistry in Senior Secondary Schools In damaturu Local Government.* Yobe State: Google.Scholar.

Koomson, C. K., Safo-Adu, G., & Antwi, S. (2020). Utilising computer simulation and computerised molecular modeling software to enhance the teaching and learning of hybridisation in senior high schools. *International Journal of Chemistry*, *4*(1), 044-055.

Le-Eere, N. G., & Ajoke, A. A. (2019). Volumetric analysis and secondary school chemistry teachers' competencies in Eleme Local Government Area, Rivers State. *Journal of Emerging Trends in Educational Research and Policy Studies*, *10*(3), 145-151.

Li, Z., Leustean, L., Inci, F., Zheng, M., Demirci, U., & Wang, S. (2019). Plasmonic-based platforms for diagnosis of infectious diseases at the point-of-care. *Biotechnology advances*, *37* (8), 107440.

Linda, R., Sulistya, S., & Putra, T. P. (2018). Development of Interactive E-Module. *Journal of Science Learning* 1(2), 21-25.

Listyarini, R. V., Pamenang, F. D., Harta, J., Wijayanti, L. W., Asyari, M., & Lee, W. (2019). The integration of green chemistry principles into small scale chemistry practicum for senior high school students. *Jurnal Pendidikan IPA Indonesia*, *8*(3), 3.

McCarthy, P., Gyan, E., & Baah-Korang, K. (2015). Multivariate analysis of academic performance of Ghanaian secondary school students: A case study of a senior high school in Ghana. *International Invention Journal of Education and General Studies*, 1(1), 9-17.

McComas, W. F. (2017). Understanding how science works: The nature of science as the foundation for science teaching and learning. *School Science Review*, *98*(365), 71-76.

McKenney, S., & Reeves, T. C. (2018). *Conducting educational design research.* Oxfordshire, England, UK: Routledge.

Monica, I., Nicholas, T., & David, K. (2015). Chemistry Teachers ' Role in Changing Practical Work from Simple ' Hands On ' Activities to More of ' Minds on ' Activities Department of Educational Communication and Technology Department of Educational Commmunication and Technology. *International Journal of Humanities and Social Science*, *5*(10), 110-118.

Msimanga, A., Denley, P., & Gumede, N. (2017). The pedagogical role of language in science teaching and learning in South Africa: A review of research 1990–2015. *African Journal of Research in Mathematics, Science and Technology Education*, *21*(3), 245-255.

Muhaimin, H., Mukminin, A., Pratama, R., & Asrial, H. (2019). Predicting factors affecting intention to use Web 2.0 in learning: evidence from science education. *Journal of Baltic Science Education*, *18*(4), 595-610.

Mwangi, J. T., & Mwangi, J. T. (2016). *Effect Of Chemistry Practicals On Students' Performance In Chemistry In Public Secondary Schools Of Machakos And Nairobi Counties In Kenya (Doctoral dissertation, University Of Nairobi).* Nairobi, Kenya: University of Nairobi Press.

Nainggolan, B., Simamora, M., & Hutabarat, W. (2019). Development of chemical element practical workbook based on projects and characters for class xii senior high school. *Jurnal Pendidikan Kimia*, *11*(3), 67-78.

National Academies of Sciences, Engineering, and Medicine. (2018). *Graduate STEM education for the 21st century.* Washington DC: National Academies Press.

Oakley, K., Hesmondhalgh, D., Lee, D., & Nisbett, M. (2014). The national trust for talent? NESTA and New Labour's cultural policy. *British Politics*, *9*(3), 297-317.

Ogundele, G. A., Olanipekun, S. S., & Aina, J. K. (2014). Factors affecting students' academic performance. *Scholars Journal of Arts, Humanities and Social Sciences ISSN*, 2347-5374.

Okorie, E. U., & Ugwuanyi, A. (2019). An investigation into the Extent of use of Practical Activities in Teaching Chemistry in Nigerian Schools. *Journal of CUDIMAC*, *6*(1), 37–44.

Olanipekun, S. S., & Aina, J. K. (2014). Improving students' academic performance in Nigerian schools: the role of teachers. *International Journal of Research in Humanities and Social Studies*, *1*(2), 1-6.

Pardjono, P. (2016). Active learning: The Dewey, Piaget, Vygotsky, and constructivist theory perspectives. *Jurnal Ilmu Pendidikan*, *9*(3), 75-86.

Paterson, D. J. (2019). Design and evaluation of integrated instructions in secondary-level chemistry practical work. *Journal of Chemical Education*, *96*(11), 2510-2517.

Penn, M., & Ramnarain, U. (2019). South African university students' attitudes towards chemistry learning in a virtually simulated learning environment. *Chemistry education research and practice*, *20*(4), 699-709.

Piaget, J. (2013). *Origin of Intelligence in the Child: Selected Works vol 3 (Vol. 3).* Routledge.

Pieters, J. (2010). The Effects of the Design and Development of a Chemistry Curriculum Reform on Teachers ' Professional Growth : A Case Study. *Journal of ScienceTeacher Education*, *21*(2), 535–557.

Pun, J. K., & Cheung, K. K. (2021). Meaning making in collaborative practical work: a case study of multimodal challenges in a Year 10 chemistry classroom. *Research in Science & Technological Education*, 1-18.

Russell, C. B., & Weaver, G. C. (2011). A comparative study of traditional, inquiry-based, and research-based laboratory curricula: impacts on understanding of the nature of science. *Chemistry Education Research and Practice*, *12*(1), 57-67.

Sadykov, T., & Ctrnactova, H. (2019). Interactive lessons with ICT in chemistry education. *Internatinal Conference of Doctoral Studies*, 35-45.

Sandi-Urena, S., Cooper, M. M., Gatlin, T. A., & Bhattacharyya, G. (2011). Students' experience in a general chemistry cooperative problem based laboratory. *Chemistry Education Research and Practice*, *12*(4), 434-442.

Schultz, M., Callahan, D. L., & Miltiadous, A. (2020). Development and use of kitchen chemistry home practical activities during unanticipated campus closures. *Journal of Chemical Education*, *97*(9), 2678-2684.

Shana, Z., & Abulibdeh, E. S. (2020). Science practical work and its impact on high students' academic achievement. *JOTSE*, *10*(2), 199-215.

Sharpe, R., & Abrahams, I. (2020). Secondary school students' attitudes to practical work in biology, chemistry and physics in England. *Research in Science & Technological Education*, *38*(1), 84-104.

Simpson, S. N., Tetteh, L. A., & Agyenim-Boateng, C. (2020). Exploring the socio-cultural factors in the implementation of public financial management information system in Ghana. *Journal of Accounting & Organizational Change*, 55-65.

Singh, A. S., & Masuku, M. B. (2014). Sampling techniques & determination of sample size in applied statistics research: An overview. *International Journal of economics, commerce and management*, *2*(11), 1-22.

Somuah, B. A., & Orodho, J. A. (2016). Challenges Inhibiting Effective Implementation of Integrated Science by science teachers at the Junior High Schools in Kwahu West Municipality. *International Journal in Management & Social Science*, *4*(4), 398-411.

Sotiriou, S. A., B. R., & Bogner, F. X. (2017). PATHWAYS – a case of large-scale implementation of evidence-based practice in scientific inquiry-based science education. *International Journal of Higher Education*, 6(2), 8-19.

Sunny, C. E., Taasoobshirazi, G., Clark, L., & Marchand, G. (2017). Stereotype threat and gender differences in chemistry. *Instructional Science*, *45*(2), 157-175.

Tettey-Wayo, J. K. (2018). Impact of Instructional Materials in the Teaching and Learning of Chemistry in Senior High Schools in the Yilo Krobo and Lower Manya Krobo Municipalities. *Academia*, 8-26.

Thompson, J., & Soyibo, K. (2017). Effects of lecture, teacher demonstrations, discussion and practical work on 10th graders' attitudes to chemistry and understanding of electrolysis. *Research in Science & Technological Education*, 20(1), 25-37.

Tobin, K., & Steinberg, S. R. (2015). *Doing educational research: A handbook.* Aylesbury, UK: BRILL.

Turner, A. (2017). Evaluating the UK House of Commons Science and Technology Committee's position on the implausible effectiveness of homeopathic treatments. *Theoretical medicine and bioethics*, *38*(4), 335-352.

Ulvik, M., Riese, H., & Roness, D. (2018). Action research - connecting practice and theory. *Educational Action Research,* 26(2), 273-287

Ural, E. (2016). The Effect of Guided-Inquiry Laboratory Experiments on Science Education Students' Chemistry Laboratory Attitudes, Anxiety and Achievement. *Journal of Education and Training Studies*, *4*(4), 217-227.

Ürek, H., & Dolu, G. (2016). Conceptual Understandings Of Seventh Grade Gifted Students Regarding Several Situations Involving Chemical Changes. *Journal of Educational & Instructional Studies in the World*, 6(1), 18 -28.

Vakili, M. M., & Jahangiri, N. (2018). Content validity and reliability of the measurement tools in educational, behavioral, and health sciences research. *Journal of Medical Education Development*, *10*(28), 106-118.

Van Bergen, P., & Parsell, M. (2019). Comparing radical, social and psychological constructivism in Australian higher education: a psycho-philosophical perspective. *The Australian Educational Researcher*, 46(1), 41-58.

Vijayasarathy, P. R. (2018). *Engineering chemistry.* New York: PHI Learning Pvt. Ltd.

Vilchez, J. L. (2019). Mental footnotes: Knowledge constructivism from logical thinking to daily functioning. *Review of Contemporary Philosophy*, *18*, 7-22.

Vinuesa, R., Azizpour, H., Leite, I., Balaam, M., Dignum, V., Domisch, S., Fellander A., Langhans, D., Tegmark, M.,& Nerini, F. (2020). The role of artificial intelligence in achieving the Sustainable Development Goals. *Nature communications*, *11*(1), 1-10.

Vorsah, R. E., & Adu-Gyamfi, K. (2021). High School Chemistry Teachers Perspectives and Practices on Teaching Mole Concept. *European Journal of Education Studies*, *8*(2), 15-25.

WAEC. (2014). *Chief Examiner's Report.* Accra, Ghana: WAEC.

Wafubwa, L. N. ((2019). *An Assesment of Practical Intergration in Enhancing Teaching and Learning of Chemistry in High Schools in Kanduyi Subcounty, Bungoma County Kenya* . Bungoma County Kenya: University of Nairobi Press.

Walter, A., Finger, R., Huber, R., & Buchmann, N. (2017). Opinion: Smart farming is key to developing sustainable agriculture. *Proceedings of the National Academy of Sciences*, *114*(24), 6148-6150.

Wei, B., & Liu, H. (2018). An experienced chemistry teacher's practical knowledge of teaching with practical work: the PCK perspective. *Chemistry Education Research and Practice* 19(2), 452-462.

West African Examinations Council (WAEC). (2018). *Chief Examiner's Report.* Accra, Ghana: WAEC.

West African Examinations Council (WAEC). (2019). *Chief Examiner's Report.* Accra, Ghana: WAEC.

West African Examinations Council (WAEC). (2021). *Senior High School Chemistry Syllabus.* Accra: WAEC.

Xyst, K. (2016). Constructivism, Dewey, and academic advising. *NACADA Journal*, *36*(2), 11-19.

Yeşiloğlu, S. N., & Köseoğlu, F. (2020). Epistemological problems underlying pre-service chemistry teachers' aims to use practical work in school science. *Chemistry Education Research and Practice*, *21*(1), 154-167.

Yuliani, G., Halimatul, H. S., Aisyah, S., & Widhiyanti, T. (2020). The Profile of

Teachers' Performance in Designing Practical Chemistry Laboratory Works. *Asian Education Symposium*, 275-278.

APPENDICES

APPENDIX A

CHEMISTRY SCHEMES OF WORK

WEEK	LESSON	TOPIC/SUBTOPIC	LESSON OBJECTIVES	LEARNING ACTIVITIES	LEARNING RESOURCES/REFS	REMARKS
1 2 3	Since senior high schools use week one for the tidying up of their compound and weeks 2 for going through previous examination questions, the researcher deemed it efficient to start the implementation of the intervention in the 4th week of the semester. This will allow the schools selected to be prepared and ready for the study.					
4	1	ALKALI METALS Electron Arrangement, Ions & trends in ionization energy	At the end of the lesson, the learner should be able to: i) Identify alkali metals in the Periodic Table. ii) Explain how they form ions. iii) Describe the trend of their I. Energy.	**CLASS DISCUSSION** **On:-**Listing and identifying the elements in P.T. -Formation of ions. -ionization energies of group 1 elements.	- Periodic Table chart. - Chart on I.E. of group 1 metals. Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 123-132. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 39-54	
	2&3	ALKALI METALS Physical properties & Reaction with air, water and chlorine	At the end of the lesson, the learner should be able to: i) Describe the physical properties of alkali metals. ii) Explain the reactions of alkali metals with air, H_2O, and Chlorine	**DEMONSTRATION EXPERIMENT** **On:-** appearance, m.p., b.p., thermal and electrical conductivity. -reactions with air, water, and chlorine.	Elements Na & K, Water, Cl_2 gas, scapel blade, Test tube racks + t.t., source of heat and electricity, litmus, pH chart. Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 123-132. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 39-54	
	4	ALKALI METALS Similarity of ions & formulae of OH^-, O^{-2} & Cl^- of alkali metals. Uses of alkali metals	At the end of the lesson, the learner should be able to: i) Write the formulae of the OH^- O^{-2} and Cl^- of alkali metals. ii)Write the word and symbol equations of the reactions of alkali metals with air, water and chlorine. iii) Explain the uses of alkali metals.	**CLASS DISCUSSION** **On:–** formulae of compounds group 1 elements. -writing equations for the reactions of group 1 elements. - explaining the uses of the elements.	Periodic Table chart, charts on formulae of alkali metal OH^-, O^{-2} and Cl^-. Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 123-132. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 39-54	

5	1	ALKALINE-EARTH METALS Electron Arrangement, Ions & trends in ionization	At the end of the lesson, the learner should be able to: i) Identify alkali-earth metals in the Periodic Table. ii) Explain how they form ions. iii) Describe the trend of their I. E.	**CLASS DISCUSSION** **On:-**Listing and identifying the elements in P.T. -Formation of ions. -ionization energies of group II elements.	- Periodic Table chart. - Chart on I.E. of group 2 metals Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 132-139. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 54-66	
	2&3	ALKALINE-EARTH METALS Physical properties & Reaction with air, water, chlorine & dilute acids	At the end of the lesson, the learner should be able to: i) Describe the physical properties of alkali-earth metals. ii) Explain the reactions of alkali- earth metals with air, H_2O, and Cl_2.	**CLASS EXPERIMENT** **On:-** appearance, m.p., b.p., thermal and electrical conductivity. -reactions with air, water, and dil. Acids. -Explain reaction with Cl_2 gas.	Elements Mg & Ca, Water, Cl_2 gas, scapel blade, Test tube racks + t.t., source of heat and electricity, litmus, pH chart, dil. HCl, dil. H_2SO_4. Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 132-139. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 54-66	
	4	ALKALINE-EARTH METALS Similarity of ions & formulae of OH^-, O^{-2} &Cl^- of alkali-earth metals. Importance of alkali-earth metals	At the end of the lesson, the learner should be able to: i) Write the formulae of the OH^- O^{-2} and Cl^- of alkali- earth metals. ii)Write the word and symbol equations of the reactions of alkali-earth metals with air, water and chlorine. iii) Explain the uses of alkali-earth metals.	**CLASS DISCUSSION** **On:–** formulae of compounds group II elements. -writing equations for the reactions of group II elements. - explaining the uses of the elements.	Periodic Table chart, charts on formulae of group II metal OH^-, O^{-2} and Cl^-. Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 132-139. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 54-66	

6	1	HALOGENS Electron configuration of F and Cl atoms, gradation in size of atoms and Ions	At the end of the lesson, the learner should be able to: i)Write the electron configuration of F & Cl atoms. ii) Explain the gradation in size of group 7 atoms and ions.	**CLASS DISCUSSION** **On:-**Listing and identifying the elements in P.T. -Formation of ions. -ionization energies of group 7 elements.	- Periodic Table chart. - Chart on I.E. of group 7 elements Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 139-151. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 66-81	
	2&3	HALOGENS Physical properties (appearance, m.p., b.p., thermal and electrical conductivity). Reaction with metals, Na, Zn, Fe and water	At the end of the lesson, the learner should be able to: i) Explain the physical properties of group 7 elements ii) Explain the reactions of group 7 elements with H_2O, metals such as Na, Zn and Fe.	**DEMONSTRATION EXPERIMENT** **On:-** Preparation of Cl_2 gas. -Physical properties of $Cl_{2(g)}$ -Its reactions with water, litmus, metals- Na, Zn,& Fe.	Reagents & apparatus for Cl_2 gas preparation. Na, Zn & Fe metals. Water, T.t. racks + t.t., source of heat and electricity, litmus paper & soln., pH chart. Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 139-151. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 66-81	
	4	HALOGENS Similarity of ions & formulae of compounds. Importance of F, Cl, Br, and Iodine	At the end of the lesson, the learner should be able to: i)Write the formulae of compounds of group 7 elements. ii) Describe the importance of group 7 elements.	**CLASS DISCUSSION** **On:–** formulae of compounds group 7 elements. -writing equations for the reactions of group 7 elements. - explaining the uses of the elements.	Periodic Table chart, charts on formulae of group 7 ions & compounds. Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 139-151. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 66-81	

7	1	NOBLE GASES (He, Ne, & Ar) Electron arrangement & gradation in size of atoms. Electron arrangement as basis of low reactivity	At the end of the lesson, the learner should be able to: i) Explain the unreactive nature of the noble gases in terms of their electron arrangement. ii) Explain the importance of noble gases.	**CLASS DISCUSSION** **On:-**Listing and identifying the elements in P.T. -atomic structure, radii & ionization energies of group 7 elements. Physical properties & uses of Noble gases.	- Periodic Table chart. - Chart on the summary of physical properties of noble gases. Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 151-153. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 81-85.	
	2&3	PROPERTIES AND TRENDS ACROSS A PERIOD Period 3 elements (Na, Mg, Al, Si, P, S, Cl, and Ar -Physical & chemical properties of period 3 elements with	At the end of the lesson, the learner should be able to: i) Identify the elements of period 3 in the P.T. ii) Describe the physical properties of the period 3 elements. iii) Explain the reactions of period 3 elements with O_2, H_2O & dil. Acids.	**CLASS DISCUSSION** **On:-**Listing and identifying the elements in P.T. **DEMONSTRATION EXPERIMENT** **On:-**Physical properties of period 3 elements. -chemical properties of period 3 elements.	Periodic Table chart, charts on physical properties of period 3 elements. Gas jars, deflagragiting spoons, period elements, O_2, H_2O & dil. Acids Ref: Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 85-95	
	4	PROPERTIES AND TRENDS ACROSS A PERIOD Electron arrangement of period 3 elements. -Importance of noble gases	At the end of the lesson, the learner should be able to: i) Write the electron arrangement of period 3 elements. ii) Explain the trends in physical and chemical properties of elements in a period.	**CLASS DISCUSSION** **On:-**Listing and identifying the elements in P.T. - summary of the properties of period 3 elements. - importance of noble gases.	Periodic Table chart. Charts on At. Size, I.E., electronic configuration of period 3 elements. Ref: Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 85-95	

APPENDIX II: FORM II CHEMISTRY SCHEMES OF WORK

WEEK	LESSON	TOPIC/SUBTOPIC	LESSON OBJECTIVES	LEARNING ACTIVITIES	LEARNING RESOURCES/REFS	REMARKS
4	1	ALKALI METALS Electron Arrangement, Ions & trends in ionization energy	At the end of the lesson, the learner should be able to: i) Identify alkali metals in the Periodic Table. ii) Explain how they form ions. iii) Describe the trend of their I. Energy.	**CLASS DISCUSSION** **On:**-Listing and identifying the elements in P.T. -Formation of ions. -ionization energies of group 1 elements.	- Periodic Table chart. - Chart on I.E. of group 1 metals. Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 123-132. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 39-54	
	2&3	ALKALI METALS Physical properties & Reaction with air, water and chlorine	At the end of the lesson, the learner should be able to: i) Describe the physical properties of alkali metals. ii) Explain the reactions of alkali metals with air, H_2O, and Chlorine	**CLAS DISCUSSION** **On:-** appearance, m.p., b.p., thermal and electrical conductivity. -reactions of alkali metals with air, water, and chlorine.	Periodic Table chart, charts on Physical and chemical properties of group 1 elements. Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 123-132. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 39-54	
	4	ALKALI METALS Similarity of ions & formulae of OH^-, O^{-2} & Cl^- of alkali metals. Uses of alkali metals	At the end of the lesson, the learner should be able to: i) Write the formulae of the OH^- O^{-2} and Cl^- of alkali metals. ii)Write the word and symbol equations of the reactions of alkali metals with air, water and chlorine. iii) Explain the uses of alkali metals.	**CLASS DISCUSSION** **On:–** formulae of compounds of group 1 elements. -writing equations for the reactions of group 1 elements. - explaining the uses of the elements.	Periodic Table chart, charts on formulae of alkali metal OH^-, O^{-2} and Cl^-. Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 123-132. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 39-54	

5	1	ALKALINE-EARTH METALS Electron Arrangement, Ions & trends in ionization	At the end of the lesson, the learner should be able to: i) Identify alkali-earth metals in the Periodic Table. ii) Explain how they form ions. iii) Describe the trend of their I. E.	**<u>CLASS DISCUSSION</u>** **On:-**Listing and identifying the elements in P.T. -Formation of ions. -ionization energies of group II elements.	- Periodic Table chart. - Chart on I.E. of group 2 metals Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 132-139. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 54-66	
	2&3	ALKALINE-EARTH METALS Physical properties & Reaction with air, water, chlorine & dilute acids	At the end of the lesson, the learner should be able to: i) Describe the physical properties of alkali-earth metals. ii) Explain the reactions of alkali- earth metals with air, H_2O, and Cl_2.	**<u>CLASS DISCUSSION</u>** **On:-** appearance, m.p., b.p., thermal and electrical conductivity. -reactions with air, water, and dil. Acids. -Explain reaction with Cl_2 gas.	Periodic Table chart, charts on Physical and chemical properties of group 2 elements. Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 132-139. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 54-66	
	4	ALKALINE-EARTH METALS Similarity of ions & formulae of alkali-earth metals. Importance of alkali-earth metals	At the end of the lesson, the learner should be able to: i) Write the formulae of the OH^- O^{-2} and Cl^- of alkali- earth metals. ii)Write the word and symbol equations of the reactions of alkali-earth metals with air, water and chlorine. iii) Explain the uses of alkali-earth metals.	**<u>CLASS DISCUSSION</u>** **On:–** formulae of compounds group II elements. -writing equations for the reactions of group II elements. - explaining the uses of the elements.	Periodic Table chart, charts on formulae of group II metal OH^-, O^{-2} and Cl^-. Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 132-139. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 54-66	

6	1	HALOGENS Electron configuration of F and Cl atoms, gradation in size of atoms and ions	At the end of the lesson, the learner should be able to: i)Write the electron configuration of F & Cl atoms. ii) Explain the gradation in size of group 7 atoms and ions.	**CLASS DISCUSSION** **On:-**Listing and identifying the elements in P.T. -Formation of ions. -ionization energies of group 7 elements.	- Periodic Table chart. - Chart on I.E. of group 7 elements Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 139-151. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 66-81	
	2&3	HALOGENS Physical properties -Reactions with metals - Na, Zn, Fe and water	At the end of the lesson, the learner should be able to: i) Explain the physical properties of group 7 elements ii) Explain the reactions of group 7 elements with H_2O, metals such as Na, Zn and Fe.	**CLASS DISCUSSION** **On:-** Preparation of Cl_2 gas. -Physical properties of $Cl_{2(g)}$ -Its reactions with water, litmus, metals- Na, Zn,& Fe.	Periodic Table chart, charts on Physical and chemical properties of group 7 elements. Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 139-151. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 66-81	
	4	HALOGENS Similarity of ions & formulae of compounds. Importance of F, Cl, Br, and Iodine	At the end of the lesson, the learner should be able to: i)Write the formulae of compounds of group 7 elements. ii) Describe the importance of group 7 elements.	**CLASS DISCUSSION** **On:–** formulae of compounds group 7 elements. -writing equations for the reactions of group 7 elements. - explaining the uses of the elements.	Periodic Table chart, charts on formulae of group 7 ions & compounds. Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 139-151. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 66-81	

7	1	NOBLE GASES (He, Ne, & Ar) Electron arrangement & gradation in size of atoms. Electron arrangement as basis of low reactivity	At the end of the lesson, the learner should be able to: i) Explain the unreactive nature of the noble gases in terms of their electron arrangement. ii) Explain the importance of noble gases.	**CLASS DISCUSSION** **On:-**Listing and identifying the elements in P.T. -atomic structure, radii & ionization energies of group 7 elements. Physical properties & uses of Noble gases.	- Periodic Table chart. - Chart on the summary of physical properties of noble gases. Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 151-153. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 81-85.	
	2&3	PROPERTIES AND TRENDS ACROSS A PERIOD Period 3 elements. -Physical & chemical properties of period 3 elements.	At the end of the lesson, the learner should be able to: i) Identify the elements of period 3 in the P.T. ii) Describe the physical properties of the period 3 elements. iii) Explain the reactions of period 3 elements with O_2, H_2O & dil. Acids.	**CLASS DISCUSSION** **On:-**Listing and identifying the elements in P.T. -Physical properties of period 3 elements. -chemical properties of period 3 elements.	Periodic Table chart, charts on physical properties of period 3 elements. Ref: Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 85-95	
	4	PROPERTIES AND TRENDS ACROSS A PERIOD Electron arrangement of period 3 elements. -Importance of noble gases	At the end of the lesson, the learner should be able to: i) Write the electron arrangement of period 3 elements. ii) Explain the trends in physical and chemical properties of elements in a period.	**CLASS DISCUSSION** **On:-**Listing and identifying the elements in P.T. - summary of the properties of period 3 elements. - importance of noble gases.	Periodic Table chart. Charts on At. Size, I.E., electronic configuration of period 3 elements. Ref: Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 85-95	

CLASS EXPERIMENT/DEMONSTRATIO N LESSON PLAN

SCHOOL………………………………………………………………………………………
DATE………………

CLASS/FORM……………………………………… TIME…………………

TOPIC…………………………………………………………………………………….

SUB-TOPIC……………………………………………………………………………

OBJECTIVES………………………………………………………………………….

…………………………………………………………………………………………

…………………………………………………………………………………………

TIME	CONTENT	LEARNING ACTIVITIES	LEARNING RESOURCES
5 mins	INTRODUCTION Review the previous work on the sub-topic. -- -----------------------------	-Question and Answer -Demonstration	List any resource to be used.
10 mins	LESSON DEVELOPMENT STEP I: Procedure of the experiment -Title -Aim -Instructions -Table of results/Observations	CLASS EXPERIMENT /DEMONSTRATION ON: ------------------------------ --------------------------- Note taking Explanation Clarification/demonstra tion	- C/W/board. - Handout if any. Reference(s)
40 mins	STEP II Experiment/Demonstration	PERFORMING THE EXPERIMENT/DEMON S TRATION	List the equipment, apparatus and the reagents to be used in the experiment.

20 mins	<u>STEPIII</u> <u>DISCUSSION</u> <u>DEDUCTIONS and EXPLANATIONS</u> From observations/results, the following points will be discussed. (i)---------------- (ii)...............	-Clean up - Question and Answer -explanations -note taking -Drawing, etc.	Results/observations Reagents/apparatus, References
5 mins	<u>CONCLUSION</u> Refer to your stated objectives when writing this step. -Decide best to check achievement of the objectives <u>ASSIGNMENT</u> Indicate the assignment to be given. <u>REMARKS</u> This should be written at the end of teaching the lesson.	May be- Q&A, highlighting, summarizing.	Reference(s)

THEORY LESSON PLAN
FORMAT

SCHOOL……………………………… DATE………………………………………...

CLASS/FORM………………………TIME…………………………………………

TOPIC……………………………………………………………………………………

SUB-
TOPIC……………………………………………………………………………………

OBJECTIVES……………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

TIME	CONTENT	LEARNING ACTIVITIES	LEARNING RESOURCES
10mins	INTRODUCTION Review the previous work on the sub-topic. --	-Question and Answer	List any resource to be used.
	LESSON DEVELOPMENT		
20 mins	STEP I: - content points on objective (i)	CLASS DISCUSSION ON: --- Note taking Explanation Clarification/demonstr-ation	- C/W/board. - Handout if any. Reference(s)
20 mins	STEP II - content points on objective (ii)	Question & Answer Explanations Note taking	Charts on:--------------- ----------------------------- ------------------------------ Reference(s)

15 mins	<u>STEPIII</u> - content points objective (iii)	- Question and Answer -explanations -note taking -Drawing, etc.	Periodic Table Chart References
10 mins	<u>STEP IV</u> Exercise	Supervised Practice Doing the Exercise	C/w/board Reference(s)
5 mins	<u>CONCLUSION</u> Refer to your stated objectives when writing this step. -Decide best to check achievement of the objectives <u>ASSIGNMENT</u> Indicate the assignment to be given. <u>REMARKS</u> This should be written at the end of teaching the lesson.	May be- Q&A, highlighting, summarizing.	References Notes Reference(s)

APPENDIX B

STUDENT ACHIEVEMENT TEST - (PRE-TEST)

This test paper consists of 5 questions. Answer all questions in the spaces provided. Do not write your name anywhere on this paper.

School…………………………….. Study ID……………

Type of school (Tick (√) as appropriate). Boys only() Girls only() Mixed ( )

DATE…………………….. TIME: 1HOUR

1. The following table gives the structures of five different atoms. Study it and answer the questions that follow. (A, B, C, D, and E do not represent the actual symbols of the elements).

Atom	Protons	Electrons	Neutrons
A	5	5	6
B	9	9	10
C	10	10	11
D	15	15	16
E	10	10	12

(a) What is the mass number of atom B? ....(1 mark)

(b) Which of the atoms has a mass number of 11? ....(1mark)

(c) Which of the atoms represent isotopes of the same element? (1mark)

(d) Give a reason for your answer in (c) above (2marks)

(e) What is the atomic number of atom D? (1mark)

2. Five elements A, B, C, D and E have the electronic arrangements shown thus: A- 2,8,1 B- 2,8,8,2 C- 2,7

D- 2,8,2 E- 2,8,8 The letters do not represent the actual symbols of the elements.

(a) Which two elements belong to the same group? Give a reason for your answer.

……………………………………………………………(2marks)

(b) Which element is an alkali metal? Give a reason for your answer……………

……………………………………………………… (2marks)

(c) Which of the elements is a highly reactive gas? Give the name of the group to which it belongs… ....(2marks)

(d) Which of the elements is the most unreactive?.....................(1mark)

(e) Which of the elements are metals?................................(1mark)

3. The table below gives the atomic numbers of the elements A, B, C, D, E, F and G. Study it and answer the questions that follow. The letters do not represent the actual symbols of the element.

Element	A	B	C	D	E	F	G
Atomic number	14	15	16	17	18	19	20

(a) Which element belongs to group II of the Periodic Table?........................... (1mark)

(b) Which element will not form an oxide? Explain………… (2marks)

(c) Give the type of structure and bonding that is present in element A… (2marks)

(d) The elements represented by F and G have very little tendency to form covalent bonds.

Explain…………………………………………………………………….(2marks)

(e) Which two elements will react most vigorously with each other? Explain……….…. (2marks)

4.(a) What is the pH scale ....(2marks)

(b) (i) State whether the solutions which have the following pH values

are acidic, basic or neutral: (3marks)

pH= 6…………………. pH= 2………………….. pH= 12……………..pH=7…………………

pH=8……………………

(ii) Which of the pH values listed above is of (2marks)

I) a strong acid………………………… . II) a weak base…………………………

III) a strong base ……………………….. IV) a weak acid………………………….

4. The table below shows the electronic arrangements of the ions of elements A to J. Study it and answer the questions that follow. The letters A to J are not the actual symbols of the elements.

Element	Ion	Electronic arrangement of ion
A	A^{+}	2,8
B	B^{2+}	2,8,18
C	C^{-}	2,8
D	D^{2+}	2,8
E	E^{+}	2
F	F^{+}	2,8,8
G	G^{2+}	2,8,8
H	H^{-}	2,8,18,8
I	I^{3+}	2,8
J	J^{-}	2,8,8

(a) Write the electronic arrangement of the neutral atom of element E. (1 mark)

…………………………………………………………………………………………

(b) Give the atomic number of element D. ……………………………………… (1 mark)

(c) Give three elements that belong to the same group of the Periodic Table. (1 mark)

…………………………………………………………………………………………

(d) State any four elements that belong to the same period of the Periodic Table. (1 mark)

…………………………………………………………………………………………

(e) State two the non-metallic elements. Give a reason for your choice. (2 marks)

…………………………………………………………………………

(f) Write the formula of the compound that would be formed between D and J. (2 marks)

…………………………………………………………………………………………

(g) Which would be larger, the atomic radius of E or its ionic radius? Explain. (2 marks)

…………………………………………………………………………………………

APPENDIX C

STUDENT ACHIEVEMENT TEST - (POST TEST)

This test paper consists of **4** questions. Answer all the questions in the spaces provided. Do not write your name anywhere on this paper.

School…………………………………. Study ID…………

Type of school: (Tick **(√)** as appropriate). Boys only () Girls only () Mixed ( )

DATE………………………….. TIME: 1HOUR

1. The grid below shows part of the Periodic Table. Use the information in the grid to answer the questions that follow. The letters do not represent the actual symbols of the elements.

A															
D												C		B	
										F	G		H		
K	L						M								
											R	Q			
P															

a) Giving reasons select:

(i) An element that can form an ion with a charge of -2. (2 marks)

……………………………………………………………………………………………

(ii) The metallic element with the lowest melting point. (2 marks)

…………………………………………………………………………………………

(iii) The non-metallic element with the highest melting point.
(2 marks)

…………………………………………………………………………………………

(b) Write down the formula of:

(i) The chloride of R. ………………………………………………… (1 mark)

(ii) The oxide of P. ……………………………………………….. (1 mark)

(c) Explain the following observations:

(i) L is a hard solid with higher melting point than K.
(1 mark)

…………………………………………………………………………………………

…………………………………………………………………………………………

(ii) The fourth ionization energy of F is much greater than the fourth ionization energy of C.

…………………………………………………………………………………………

…………………………………………………………………………………………
…
(1 mark)

(d) Select any two elements which when combined:

(i) Form a compound that conducts electricity in both fused state and in solution.

…………………………………………..
(1 mark)

(ii) and dissolved in water form an acidic solution………………(1 mark)

2. Chlorine is bubbled through aqueous solutions containing fluorides, bromide and iodide ions in turn. Enter the observations you would expect to make and give an explanation in each case in the table below. (6 marks)

Solutions of	Observation	Explanation
Fluoride ions		
Bromide ions		
Iodide ions		

3. (a)The information in the table below shows the ionization energies of the elements marked A, B, and C. Use it to answer the questions that follow.

Element	First ionization energy $KJmol^{-1}$
A	494
B	519
C	418

(i) Which element has the smallest atomic radius? Explain. (2 marks)

……………………………………………………………………………………

……………………………………………………………………………………

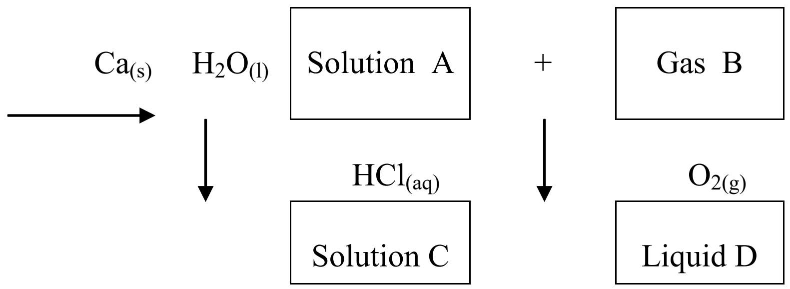
(ii) Which element has the lowest melting and boiling points?
……………………….. (1 mark)

(iii) Which element would be a better conductor of both heat and electricity? Explain. (2 marks)

……………………………………………………………………………………

……………………………………………………………………………………

(b) The reactions of calcium are typical of a group 2 element. Write the formulae for substances A – D shown in the flow chart below. (8 marks)



A.………………………………..   B.……………………

C.………………………………..   D.……………………

4. An imaginary new element called kenonium (symbol, Ke) has been discovered. The element is a soft solid, which is easily cut with a knife to reveal a shiny surface that soon tarnishes. It reacts violently with water to form a highly inflammable gas and a strongly alkaline solution.

(a) To what group of the Periodic Table would you assign the element? (1 mark)

(b) Give a symbolic equation of the reaction between the element and water. (1 mark)

…………………………………………………………………………………………

(c) Would you expect the element to react with chlorine? If so, explain and give the formula of the expected product.

(2 marks)

…………………………………………………………………………………………

…………………………………………………………………………………………

(d) Give the formulae for the kenonium: (4 marks)

(i) oxide…………… (ii) carbonate………………(iii) nitrate…………..

(e) What would be the best way to store the element? Give a reason for your answer. (2 marks)

…………………………………………………………………………………………

APPENDIX D

TEACHERS' QUESTIONNAIRE

The purpose of this questionnaire is to obtain information about the effect of chemistry practical activities on learners' performance in chemistry in Sekondi-Takoradi Metropolitan area in the Western Region of Ghana. Your school is one of those that have been sampled for the study. Do not indicate your name on the questionnaire. Please answer all the questions honestly.

Please answer the questions by ticking (√) in the brackets or write in the spaces provided.

School……………………… Type of school: Boys only ( )

Girls only ( ) Mixed ( )

Date…………………

Section A: Personal Information

Gender: Male ( ) Female ( )

Age: 20 – 25 years ( ) 26 – 30 years ( ) 31 – 40 years ( )

41 years and above

Qualification: Degree ( ) Masters ( ) PHD ( )

Employment Status: Full Time ( ) National Service ( ) Intern ( )

Section B: Teacher Expectations

1. How would you rate the level of discipline among your students? ------------------

5= very disciplined 4= disciplined 3= not sure

2= undisciplined 1= very undisciplined

2. How would you rate the attitude of your students towards the following?

5= excellent 4= good 3= fair 2= poor

1= negative

Respond by ticking (√) in the column with most appropriate number depending on how you rate each of the following statements.

	Statements	**5**	**4**	**3**	**2**	**1**
a	Science subjects					
b	Chemistry subject					
c	Chemistry assignments					
d	Chemistry practicals					
e	Chemistry theory lessons					

3. How would you rate your students in terms of the following criteria?

5= very high 4= high 3= average 2= low 1= very low

Respond by ticking (√) in the column with most appropriate number depending on how you rate each of the following statements.

	Statements	**5**	**4**	**3**	**2**	1
a	Academic ability					
b	Academic ability in sciences					
c	Academic ability in chemistry					
d	Ability in chemistry practicals					

4. How would you rate your students in terms of the following characteristics?

5= very strong 4= strong 3= average 2= weak

1= very weak Respond by ticking (√) in the column with most appropriate number depending on how you rate each of the following statements.

	Statements	**5**	**4**		**3**	**2**	**1**
a	Making accurate observations						
b	Interest in doing investigation						
c	Using theory when doing investigations						
d	Keeping neat and accurate records						
e	Ability to make accurate interpretation and Predictions						
f	Eagerness to investigate after school						
g	Eagerness to relate observations to theory work						

5. The following teaching/ learning resources in your school are rated as adequate. Do you: **5**=(Strongly Agree), **4**=(Agree), **3**=(Not Sure), **2**=(Disagree), **1**=(Strongly Disagree)? Respond by ticking (√) in the column with most appropriate letter(s) depending on how you feel about each of the following resources.

	Statements	5	4	3	2	1
a	Chemistry laboratory/s - (space and equipment)					
b	Chemistry apparatus and reagents					
c	Relevant chemistry text books					
d	Classrooms					
e	Qualified chemistry teachers					
f	Time for teaching chemistry					
g	Time for chemistry practicals					

Section C: Teacher practices

1) How frequently do you adopt the following teaching strategies while teaching chemistry to your students?

5= very frequently **4**= frequently **3**= occasionally **2**= never **1**= I don't know Respond by ticking (√) in the column with most appropriate number depending on how you rate each of the following statements.

	Statements	5	4	3	2	1
a	Discussion only					
b	Demonstration experiment only					
c	Demonstration experiment and discussion					
d	Demonstration experiment in the classroom					
e	Class Experiment of 1or 2 students per group					
f	Class Experiment of >5 students per group					

2) What percentage of your chemistry lessons is chemistry practical activity? Respond by ticking (√) in the appropriate space.

100% ( ) 75% ( ) 50% ( ) 25% ( ) 0% ( )

3) How much of your chemistry lessons is student chemistry practicals? Respond by ticking (√) in the appropriate space.

100% ( ) 75% ( ) 50% ( ) 25% ( ) 0% ( )

4) How much of your chemistry lessons is teacher demonstrations? Respond by ticking (√) in the appropriate space.

100% ( ) 75% ( ) 50% ( ) 25% ( ) 0% ( )

5) How would you rate the following statements about chemistry practicals? Indicate: **5**=(Strongly Agree), **4**=(Agree), **3**=(Not Sure), **2**=(Disagree), **1**=(Strongly Disagree)? Respond by ticking (√) in the column with most appropriate letter(s) depending on how you feel about each of the following statements.

	Statements	**5**	**4**	**3**	**2**	**1**
a	Chemistry practicals increase understanding					
b	Chemistry practicals increase enjoyment					
c	Pressure to cover syllabus is an obstacle to chemistry practicals					
d	Pressure on teachers to ensure good grades is an obstacle to chemistry practicals					
e	Chemistry practicals increase achievement of good grades					
f	Chemistry practicals reduce syllabus coverage					
g	Chemistry practicals are humdrum (monotonous) and routine, rather than engaging or inspiring.					
h	Chemistry practicals drills and practices only for passing examinations					
i	Teachers' work load is an obstacle to chemistry Practicals					
j	Large numbers of students are obstacles to chemistry practicals					

APPENDIX E

STUDENTS' QUESTIONNAIRE

The purpose of this questionnaire is to obtain information about the effect of chemistry practical activities on learners' performance in chemistry in Sekondi-Takoradi Metropolitan area in the Western Region of Ghana. Your school is one of those that have been sampled for the study. Please answer the questions by ticking (√) in the brackets or write in the spaces provided.

School………………………………………………….. Study ID………….

Date………………… Type of school: Boys only ( ) Girls only ( ) Mixed ( )

Section A: Personal Information

Gender: Male ( ) Female ( )

Age: 15 – 17 years ( ) 18 – 20 years ( ) Above 21 years ( )

Section B - Students Characteristics

1. How would you rate the level of discipline among students in your class? --------------

5= very disciplined **4**= disciplined **3**= not sure

2= undisciplined **1**= very undisciplined

2. How would you rate your attitude towards the following?

5= excellent **4**= good **3**= fair **2**= poor **1**= negative

Respond by ticking (√) in the column with most appropriate column depending on how you rate each of the following statements.

	Statements	1	2	3	4	5
a	Science subjects					
b	Chemistry subject					
c	Chemistry assignments					
d	Chemistry practicals					
e	Chemistry theory lessons					

3. How would you rate yourself in terms of the following criteria?

5= very high **4**= high **3**= average **2**= low **1**= very low

Respond by ticking (√) in the column with most appropriate number

depending on how you rate each of the following statements.

	Statements	1	2	3	4	5
a	Academic ability					
b	Academic ability in sciences					
c	Academic ability in chemistry					
d	Ability in Chemistry practicals					

4. How would you rate yourself in terms of the following characteristics?

5= very strong **4**= strong **3**= average **2**= weak

1= very weak Respond by ticking (√) in the column with most appropriate number depending on how you rate each of the following statements.

	Statements	**1**	**2**	**3**	**4**	**5**
a	Making accurate observations in chemistry practical activities					
b	Interest in doing investigations in chemistry					
c	Using theory when doing investigations in Chemistry					
d	Keeping neat and accurate records of chemistry practical activities					
e	Ability to make accurate interpretation and predictions during chemistry practical activities					
f	Eagerness to do science investigations after School					
g	Eagerness to relate observations to theory work					

Section C: Teaching/Learning Resources

1. The following teaching/ learning resources in your school are rated as adequate. Do you **5**=(Strongly Agree), **4**=(Agree), **3**=(Not Sure), **2**=(Disagree), **1**=(Strongly Disagree)? Respond by ticking (√) in the column with most appropriate letter(s) depending on how you feel about each of the following resources.

	Statements	**1**	**2**	**3**	**4**	**5**
a	Chemistry laboratory/s - (space and equipment)					
b	Chemistry apparatus and reagents					
c	Relevant chemistry text books					
d	Chemistry teachers					
e	Time for learning chemistry					
F	Time for chemistry practical activities					

2. How frequently are the following teaching methods used while chemistry is being taught in your class?

5= very frequently **4**= frequently **3**= occasionally **2**= never

1=don't know Respond by ticking (√) in the column with most appropriate number depending on how you rate each of the following statements.

	Statements	**1**	**2**	**3**	**4**	**5**
a	Discussion/Lecture only					
b	Teacher demonstration experiment only					
c	Demonstration experiment followed by discussion in the lab. or in class					
d	Demonstration experiment in the classroom					
e	Students experiment of 1or 2 students per group					
f	Students experiment of >5 students per group					

3) What percentage of your chemistry lessons is Chemistry practical? Respond by ticking (√) in the appropriate space.

100% ( ) 75% ( ) 50% ( ) 25% ( ) 0% ( )

4) How much of your chemistry lessons is student chemistry practicals? Respond by ticking (√) in the appropriate space.

100% ( ) 75% ( ) 50% ( ) 25% ( ) 0% ( )

5) How much of your chemistry lessons is teacher demonstrations? Respond by ticking (√) in the appropriate space.

100% ( )   75% ( )   50% ( )   25% ( )   0% ( )

6. How would you rate the following statements about chemistry practicals? Indicate: **5**=(Strongly Agree), **4**=(Agree), **3**=(Not Sure), **2**=(Disagree), **1**=(Strongly Disagree)? Respond by ticking (√) in the column with most appropriate letter(s) depending on how you feel about each of the following statements.

	Statements	**1**	**2**	**3**	**4**	**5**
a	Chemistry practical activities increase understanding of Chemistry					
b	Chemistry practical activities increase enjoyment					
c	Chemistry practical activities are an obstacle to syllabus Coverage					
d	School timetable is an obstacle to chemistry practical activities					
e	Chemistry practical activities increase achievement of good grades					
f	Chemistry practical activities reduce syllabus coverage					
g	Chemistry practical activities are humdrum (monotonous) and routine, rather than engaging or inspiring.					
h	Chemistry practical activity drills and practices only for passing examinations					
i	Gender of students is an obstacle to chemistry practical activities					
j	Large numbers of students are obstacles to chemistry practical activities					