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UTILISATION OF CHEMISTRY LABORATORY RESOURCES FOR TEACHING AND LEARNING IN THE SECOND CYCLE INSTITUTIONS IN THE AKUAPEM SOUTH MUNICIPALITY

ADELINE BEDJABENG

MASTER OF PHILOSOPHY

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DECLARATION

STUDENT'S DECLARATION

I ADELINE BEDJABENG declare that this thesis, with the exception of quotations and refences contained in published works which have all been identified and duly acknowledged, is entirely original work and has not been admitted, either in part or whole, for another degree elsewhere.

SIGNATURE:……………………..………

DATE:………………..……………...……

SUPERVISOR'S CERTIFICATION

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

NAME OF SUPERVISER: DR. JAMES A. AZURE

SIGNATURE:…………………………..………

DATE:…………………..……………...……

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DEDICATION

I dedicate this project work to my daughter Roselyn A. A. Darko and my mum Esther A. Pankyea Bedjabeng.

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All glory and honor belong to my heavenly Father, whose mercy and grace made it possible for this project to be finished.

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TABLE OF CONTENTS

University of Education,Winneba http://ir.uew.edu.gh

University of Education,Winneba http://ir.uew.edu.gh

University of Education,Winneba http://ir.uew.edu.gh

University of Education,Winneba http://ir.uew.edu.gh

LIST OF TABLES

University of Education,Winneba http://ir.uew.edu.gh

LIST OF FIGURES

Figure **Page**

University of Education,Winneba http://ir.uew.edu.gh

ABSTRACT

Quality and effective teaching of Chemistry depends largely on adequate provision and proper utilisation of instructional resources. The purpose of this study was to explore the extent of utilisation of chemistry laboratory resources for teaching and learning in the second cycle institutions in the Akuapem South Municipality. Descriptive survey research design was employed. Purposive sampling technique was used in selecting 100 participants for the study. Structured questionnaire and observation were used to collect primary data. The reliability of the questionnaire was 0.79. Data collected was analysed using the Statistical Package for Social Science (SPSS) version 23.0. The study revealed that most of the laboratory substances such as reagents and solutions are occasionally available while some are not available at all. With respect to their adequacy, the study found out that most of the resources are not adequate in the chemistry laboratory. Similarly, the study revealed that a good number of the apparatuses and equipment's are only used occasionally such as during terminal and external examinations whiles others are not used at all. Again, the study revealed several challenges chemistry teachers face in teaching practical's which include time allocation of practical work on the time table and large class size with limited laboratory space. The study recommended that all the science laboratories in senior high schools should be equipped with modern equipment and other necessary teaching aids or instructional materials. The provision of these materials/equipment will help both teachers and students in the teaching and learning process.

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CHAPTER ONE

INTRODUCTION

1.0 Overview

Chapter one consists of the background to the study, statement of the problem, purpose of the study, research objectives, research questions, significance of the study, delimitation, limitation of the study, operational definition of terms and organisation of the Work.

1.1 Background to the Study

Learning refers to the changes and modification in the individual which the learner undergoes from birth till death. Academic learning is a process of changes and modification that takes place in classroom or school (Tatli, & Ayas, 2013). Learning occurs through one's interaction with one's environment. In school, environment refers to the different facilities available to facilitate students learning outcome. Among the physical facilities are land, building, library, museum, and laboratory facility which is one of the most important and has been observed as a potent factor to quantitative learning (Zeyneps & Alipase, 2011). No course in science can be considered as complete without including some practical work in it. The practical work is to be carried out by an individual in a physical science laboratory. Most of the achievements of modern science are due to the application of the experimental method.

Globally, Chemistry is one of the fundamental ingredients of science and technology (Davis, 2013). It is a branch of science that deals with the practical and experimental understanding of natural phenomena. As a science subject and a medium for inquiry, it is the primary process by which scientific knowledge is gained. One of the most effective ways by which the process of inquiry can be learnt is a laboratory where the

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students can get first-hand experiences (Joanne, 2004). Thus, studying in a laboratory is an integral and essential part of science in general and chemistry.

The subject forms an integral part of the science curriculum in the Senior High Schools in Ghana. It serves as the basis for higher studies in science related courses at high institutions. At the school stage, practical work is more important because students 'learn by doing' and scientific principles and applications are rendered more meaningfully. Quality and effective teaching of Chemistry depends largely on adequate provision and proper utilisation of instructional resources. A practical based approach to Chemistry is the key to breakthrough in Science and Technology advancement.

According to Akçayir (2016), when science laboratories equipment is utilised effectively in the teaching and learning process, they instill in students' skills and abilities to pose scientifically oriented questions, design experiments, perform practical science activities, articulate, and rescript scientific enlightenments, converse and defend scientific arguments. Therefore, a Chemistry laboratory as a learning resource plays a very crucial role in the teaching of the subject and has a significant relationship to students' academic achievement. However, Glewwe (2013), contend that availability of school resources on their own cannot bring much meaning as pertains to students' academic performance unless the same resources are utilised effectively. Despite the priority which the national policy on education places on science subjects at all levels of education, it is not very sure whether much has been done in providing well equipped chemistry laboratories in Government Senior Higher Schools in the Akuapem south Municipality of Ghana and if there are, one is not too sure of their proper use. Therefore, the study investigates the Utilisation of Chemistry Laboratory Resources specifically in the Akuapem south Municipality of Ghana. The practical work in school helps

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students to understand the fundamental concepts in science, which develops their interest in the course.

1.2 Statement of the Problem

The performance of students in chemistry has been consistently poor in the Akuapem South Municipality in the Eastern Region of Ghana. This is a matter of national concern because chemistry is a crucial subject and serves as a gateway to various careers. The low performance indicates that learners are not acquiring the necessary knowledge and skills outlined in the chemistry syllabus.

Several recent studies have been conducted in response to these concerns, and they have all reached the same conclusion that practical activities in schools, both in Ghana and worldwide, are poorly organized and require improvement. Insufficient teaching methods (Friedman, 2000), inadequate investment in science resources, particularly in chemistry and biology facilities (Agusiobo, 1998), low teacher motivation, inadequate internal evaluation, ineffective administration and leadership, insufficient supervision and inspection of school facilities including laboratories (Chiriswa, 2002), and various other factors contribute to these complaints. Notably, Orado's study (2009) conducted in Nairobi revealed a consistent pattern of underperformance in the practical component of the national Chemistry exam, resulting in overall poor academic outcomes in the subject. Scientific studies by Asmah *et al*. (2021) on the "knowledge base of chemistry Teachers support materials used in teaching practical skills in titration in senior high schools in Ghana" indicate that senior high school students should have more opportunities to engage in hands-on laboratory activities to enhance their planning, performance, and critical thinking skills. However, this is not currently taking place in Ghanaian classrooms.

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The percentage scores of students offering chemistry from 2019 to 2021 in selected schools within the Akuapem South Municipality, according to reports from WAEC (2019, 2020, 2021), are as follows: Aburi Presbyterian Senior High (A1-C6 - 73 (81.11%), 44 (23.66%), 56 (57.73%)), Adonten Senior High (A1-C6 - 114 (98.28%), 119 (79.33%), 127 (90.07%)), Aburi Girls' Senior (A1-C6 - 320 (85.28%), 333 (83.33%), 317 (89.63%)), and Diaspora Girls' (A1-C6 - 193 (72.39%), 216 (79.89%), 254 (85.53%)). A pilot study conducted in these schools, namely Adonten Senior High and Aburi Girls Senior, revealed that the low performance of students may be attributed to under utilisation of available laboratory resources by teachers, leading to poor performance in practical work. Furthermore, the schools lack the necessary facilities for teachers to effectively utilise. The WAEC Chief Examiners' Reports (2019, 2020, 2021) also indicate the continued setbacks in the study of chemistry, as evidenced by students' poor performance in the subject over time.

The recurring factor contributing to this trend is poor instructional strategy (Asmah *et al*., 2021). In the Senior High School Certificate Chemistry Examinations, this has resulted in inadequate scientific language expression, difficulty in following instructions, poor question interpretation, and inadequate definitions (Asmah *et al*., 2021).

Quality science education necessitates students' direct involvement in conducting experiments. Learning and practicing chemistry cannot be achieved in an environment that does not prioritise practical and hands-on activities in schools. These findings demonstrate that students' lack of practical skills is the main factor behind their difficulties in learning and achieving high levels of performance in chemistry. The guidelines also recommend that candidates be exposed to practical work from their first year of senior high school and that laboratories be adequately equipped with modern

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equipment and facilities. Chemistry and science, in general, have their roots in observation and experimentation. Unfortunately, the majority of science courses in schools lack any form of practical work (Azure, 2015). Many students tend to view chemistry as abstract and irrelevant to their lives because teachers do not engage them in practical activities and fieldwork that would enhance their understanding of challenging concepts in the curriculum. It is believed that learners can achieve more if given the opportunity to conduct laboratory experiments based on what they have been taught in the classroom.

Therefore, this study aims to assess the extent to which chemistry laboratory facilities are utilised in the teaching and learning of chemistry in the Akuapem South Municipality.

1.3 Purpose of the Study

The purpose of the research work was to investigate the utilisation of chemistry laboratory resources for teaching and learning in the second cycle institutions in the Akuapem South Municipality.

1.4 Research Objectives

The objectives of the study are to:

1. assess the availability of chemistry laboratory facilities in second cycle institutions in the Akuapem South Municipality.
2. examine the utilisation of chemistry laboratory facilities in second cycle institutions in the Akuapem South Municipality
3. find out the laboratory skills acquired by students in the Akuapem South Municipality

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4. examine the challenges Chemistry teachers face in using laboratory facilities for teaching and learning.

1.5 Research Questions

1. What are the chemistry laboratory facilities available in the second cycle institutions in the Akuapem South Municipality for teaching and learning?
2. What is the level of utilisation of the available Chemistry laboratory facilities in the second cycle institutions in the Akuapem South Municipality?
3. What laboratory skills are acquired by students in second cycle institutions in the Akuapem South Municipality?
4. What are the challenges chemistry teachers face in using laboratory resources for teaching and learning?

1.6 Significance of the Study

It was hoped 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 sensitise them on better ways of organising and using the Chemistry laboratories. It would also help them in utilising existing facilities and in setting up new ones.

Regarding students, the findings would sensitise them on the importance of laboratory experience in their studies.

School Principals on the other hand will be informed on the various requirements needed in Chemistry laboratory and therefore use the findings to sensitise teachers, students, and parents on the importance of Chemistry laboratory in teaching thus the need to order for chemicals and apparatus.

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The findings would also provide school laboratory technicians with better ways of organising Chemistry laboratories for easier retrieval of apparatus and chemicals.

Additionally, the research would enable Chemistry curriculum developers to have an insight into the practical activities which are useful in making the learners understand the scientific concepts and principles.

The findings will also add up to existing body of knowledge concerning availability and utilisation of laboratory resources in second cycle institutions in Ghana.

It would also stimulate the interest of future researchers to undertake further investigation.

1.7 Delimitations of the Study

The delimitation of this study is influenced by the context and geographical coverage. Contextually, the study investigates the utilisation of chemistry laboratory facilities for teaching and learning in public second cycle institutions in the Akuapem South Municipality. Geographically, the study focuses on second cycle institutions in the Akuapem South Municipality in the Eastern Region of Ghana. The municipality was sampled because of convenience and adequacy of population with the characteristics of the variables under study.

1.8 Limitations of the study

Transmission hitches, data expense and job tasks were major challenges in pursuit of academic project of such magnitude. Scarcity of information, and publications especially in third world economy as ours, served as constraints to information gathering.

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Time was a constraint, combining the academic and research work, finance was also another aspect of the constraint because every movement for the research activities required money. The sample size is small so the results cannot be applied across the regions.

The researcher again faced the challenge of collecting data from respondents and most especially from the teachers since they were preoccupied with official work other than attending to the researcher.

1.9 Organisation of the Study

This thesis was divided into five major chapters. Chapter one contains an introduction, statement of the problem, purpose of the study, research objectives, research questions, significance of the study, delimitation, limitation of the study, operational definition of terms and organisation of the Work. A review of related literature is found in Chapter two. In Chapter three, the research methodology employed is described, including: research approach, research design, the population, sample and sampling technique, data source, instrumentation, procedures, and data analysis, validity, and reliability as well as ethical considerations. Chapter four contains the presentation, analysis and discussion of the data collected in the study. Finally, in Chapter five, the researcher provides a summary of the findings of the study and conclusions. Recommendations are made for future practices to address identified deficient practices and to strengthen positive practices already in place. Suggestions for future research are addressed in this chapter as well.

1.10 Definition of Terms

Amphoteric Substances: Are substances that can act either as an acid or base since they can both donate or accept a proton.

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Chemistry: A branch of science that deals with the study of structure and composition of Substances and the way they behave under different circumstances.

Demonstration: A method of teaching whereby someone shows a process or how certain things are done as others observe.

Laboratory: A room equipped with necessary equipment's for carrying out experiments which is used by teachers and students for the study of any science subject.

Laboratory Technician: A person whose occupation is to work in the laboratory, by helping to design, monitor experiments, record, and report on results.

Performance in chemistry: The grades students get in Chemistry examinations.

Practical: Use of apparatus and chemicals to observe phenomena.

Public schools: Schools supported by government especially in paying students' tuition fees and hiring teachers.

Resources: Anything that is used to help in the process of teaching and learning.

Sciences: Biology, Chemistry, Physics and Agricultural Science as taught in secondary schools

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CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter looks at researched literature pertaining to Chemistry laboratories. It goes into details of; theoretical framework which entails the instructional material theories, sociocultural theory of teaching, learning and development, Jerome Bruner's constructivism theory, conceptual framework, the roles of laboratory work, skills taught in the laboratory, methods of teaching Chemistry and utilisation of laboratory resources.

2.1 Theoretical Framework

A theory is a system that explains phenomena by stating constructs and the laws that interrelate these constructs and cognitive development to each other (Mugenda & Mugenda, 2003). Ofosu-Anim (2021) defines theories as statements about how concepts and variables relate to the purpose of explaining why things happen as they do.

This research work is rooted in the Instructional Material Theories, Lev Vygotsky's Sociocultural Theory of Teaching, Learning, and Development and Jerome Bruner's constructivism theory.

2.1.1 Instructional Material Theories

Instructional material theories assume that there is a direct link between the materials that the teachers use, and the students' learning outcomes. These outcomes include higher abilities to learn, quality strategies to learn and perform classroom activities and positive attitude towards learning. Further, these theories assume that instructional materials have the capacity to develop into students the highest order of intellectual

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skills as they illustrate clearly, step by step how to follow the rules/principles and elaborate on the concepts, all of which have positive impact on solving new problems by analysing the situation and formulating a plan (Gagne *et al*., 2005). According to Gagne *et al.,* (2005) instructional material can be used to develop higher learning abilities to the learners through self-teaching or guided learning. This implies that the instructional materials mainly comprise "eliciting performance" and "providing feedback on performance correctness," in addition to "providing learning guidance" for guided discovery learning (Shariffudin, 2007). However, the theory does not relate to whether students can think critically in what aspects or how they can solve a particular problem by themselves. However, the researcher is of the opinion that the purpose of instructional materials in education is to stretch students' imagination and to encourage them to solve problems in their lives.

Similar ideas are held by Lev Vygotsky, a Russian psychologist who held a view that tools and signs, which are in a form of instructional materials, have the capacity to develop in students' higher level of thinking, which is important in problem-solving activities. However, since they are domain-specific, the ways instructional materials can start cognitive development is yet to be studied with respect to classroom teaching. Thus, this study stretches these views (McLeod, 2020).

2.1.2 Sociocultural Theory of Teaching, Learning, and Development

The sociocultural theory of teaching, learning and development is the second theory that framed this study. Largely inspired by the seminal works of Lev Vygotsky, this theory assumes that human minds do not develop by virtue of some predetermined.

According to Vygotsky, the human mind develops through interaction with materials in the learning process where people learn from each other and use their experiences to

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successfully make sense of the materials they interact with. These experiences are crystallised in 'cultural tools', and the learners must master such tools in order to develop specific knowledge and skills in solving specific problems and, in the process, become competent in a specific profession. In the classroom, these tools can be a picture, a model, or pattern of solving a problem. Most often however, such tools are combinations of elements of different orders, and human language is the multi-level tool par excellence, combining culturally evolved arrangements of meanings, sounds, melody, rules of communication, and so forth (McLeod, 2020).

Learning by using such tools is not something that simply helps the mind to develop. Rather, this kind of learning leads to new, more elaborate forms of mental functioning. For example, when children master such a complex cultural tool as human language, this results not only in their ability to talk but leads to completely new levels of thinking, self-regulation, and mentality in general. It is the specific organisation of this tool (e.g., the semantic, pragmatic, and syntactic structures of language) that calls into being and in effect shapes and forms new facets of the child's mind. Importantly, cultural tools are not merely static 'things' but embodiments of certain ways of acting in human communities. In other words, they represent the functions and meanings of things, as discovered in cultural practices: they are "objects-that-can-be used- for-certain-purposes" in human societies. As such, they can be appropriated by a child only through acting upon and with them, that is, only during actively reconstructing their meaning and function. And such reconstruction of cultural tools is initially possible only in the process of cooperating and interacting with other people who already possess the knowledge (i.e., the meaning) of a given cultural tool (Newman & Holzman, 2013).

This short account is presented here to illustrate the fact that the sociocultural approach, unlike that of instructional materials by Gagne discussed above, not only allows for a

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synthesis of teaching, learning, and cognitive development; it actively calls for it. This theory implies that instructional materials lead to cognitive development because they mediate learners' thinking through the tools, and such mediation constitutes the very cornerstone of mental development.

2.1.3 Jerome Bruner's constructivism theory

Jerome Bruner's constructivism theory argues that learning is an active process in which learners construct new ideas or concepts based upon their current or past knowledge, (Bruner, 1996). He also argues that humans generate knowledge and meaning from interaction between their experiences and their ideas. The theory is associated with pedagogic approaches that promote active learning and discovery processes. Hands on experiences are therefore necessary for effective learning as the learner is required to do something in the process of learning. The teacher should try and encourage students to discover principles by themselves. Chemistry teachers can achieve this by giving practical in the laboratory. The various laboratory experiences expose the learners to hands on activities thus actively participating in the learning process. If well planned in a properly set laboratory, laboratory experiences can develop scientific thinking and develop practical abilities.

2.2 Conceptual Framework

The conceptual framework of the study (figure 1) relates the various ways or methods of teaching Chemistry. A hand on activities intensifies the understanding of various chemistry concepts. Though several methods can be used to teach Chemistry, Dale (2016), observes that different methods require different resources. It is therefore the role of the teacher to choose the most appropriate method to use. However, the method to be adopted for use depends on several factors. According to Wellington (2017), these factors include the learner, the learning objectives, and resources available as the

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determinant factors for teaching sciences. The teacher should consider the objective to be achieved, the learner and the nature of the content to be taught. Equally, the science teacher should be well equipped with the use of a variety of methods and procedures of teaching science. Layton (2018) indicates that whichever method a teacher adopts for a lesson, it must aim towards effectiveness in quantity (quality benefiting the learners) and quality (effectiveness) of learning. Most learning tasks involve a combination of any of the following process: recognition, memory algorithmic, problem solving, understanding and change of attitude. To achieve any of these processes requires a particular instructional approach or a combination of approaches. In senior high school teaching, the chemistry content is well elaborated in the chemistry syllabus.

The syllabus provides the objectives for teaching chemistry as well as the time limit for every topic. The syllabus is thus very important in teaching chemistry and a chemistry teacher is expected to implement the curriculum through teaching the content as it is in the syllabus. The methods of instruction vary depending on the nature of the content. Some content involves theory work, and the instruction can be in classroom. These include concepts, laws, use of various substances and applications of various processes in real life situations. However, others involve practical work and can only be taught using a Chemistry laboratory. These include acquisition of skills such as handling of apparatus, reading calibrations, observing phenomena and ability to follow procedures (manipulative skills). Also taught in the laboratory are the various process skills. The theory and the practical concepts complement each other.

The theory and the practical content are therefore equally important and should be taught effectively to realise good results. Performance in Chemistry depends on how well the two are done. In teaching Chemistry, the syllabus is the main reference. Teaching can be done using various methods. It can also be done in various places. The

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theory can be taught in the classroom while the practical is done in the laboratory. Both theory and practical reinforce each other. This study focused on the practical work done in the laboratory.

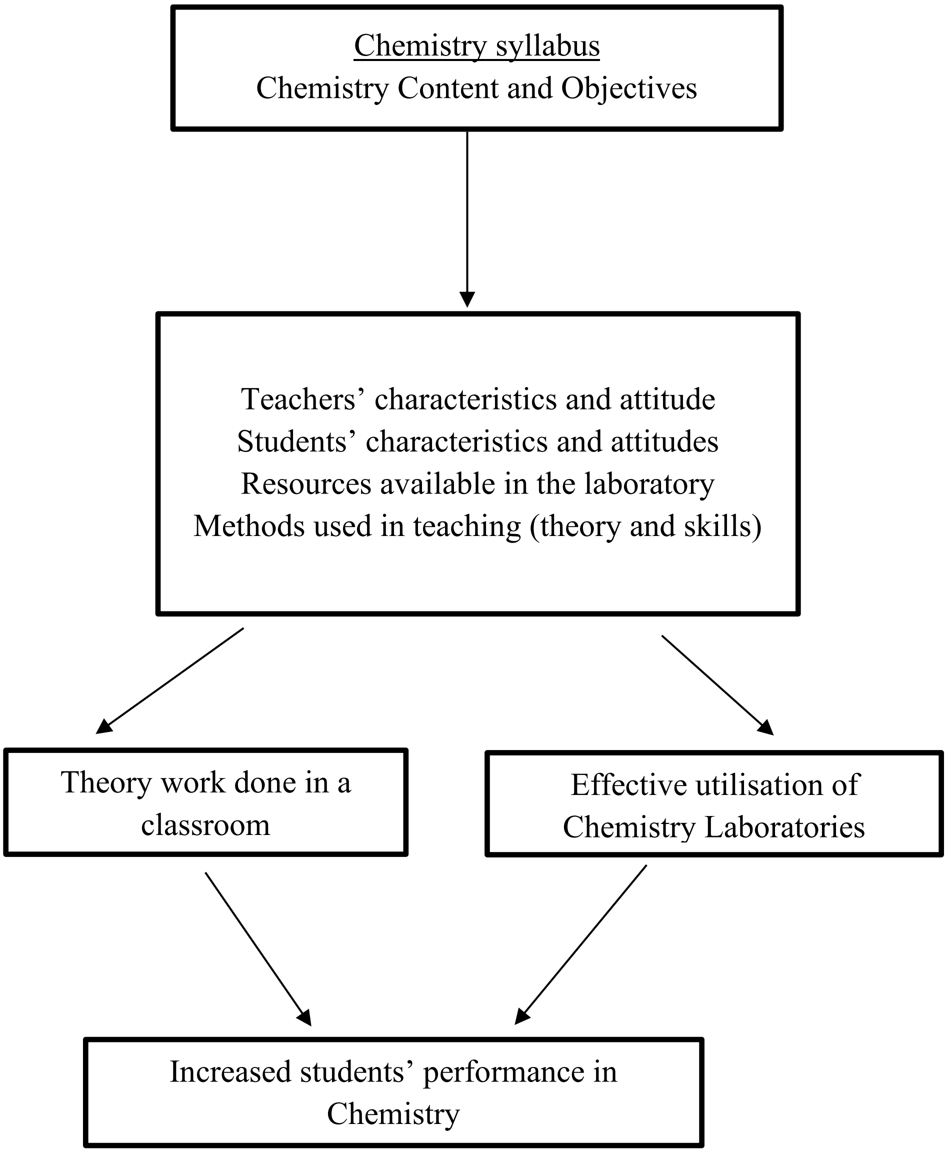

Figure 1: Conceptual Framework

Source: Njoka, 2011

2.3 Role of Laboratory Work in Chemistry

The science laboratory has a direct effect on both students' attitudes and academic performance as per the instructional theory of learning interaction. It is generally believed that constant practice leads to proficiency in what the learner learns during

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classroom instruction; hence, the dictum "practice makes perfect" (Pareek, 2019). The quality of teaching and learning experience depends on the extent of the adequacy of laboratory facilities in secondary schools and the teacher's effectiveness in the use of laboratory facilities with the aim of facilitating and providing meaningful learning experiences in the learners. Investigating the relationship between adequacy and academic performance in chemistry (Mogaka, & Ogeta, 2017). examined the adequacy of laboratory facilities using frequency counts and percentages.

Abdullahi (2017) examined the adequate use of laboratory facilities during science instruction helps to develop values that aid the learners in decision-making. Igbara, & Okeke (2015) studies also examined the adequacy of laboratory facilities and academic performance in basic sciences. Chemistry is a practically oriented science subject which presents students with abstract ideas. This is because it deals with invisible concepts such as atoms. The only way to remove the abstractness of the subject is to give students experiences that can enhance their understanding of the subject. Most of these experiences can only be given in the laboratory (Ekesi *et al.*, 2009). Miller (2004) observes that abstract ideas cannot simply be transferred from teacher to students. The students must play an active role in appropriating these ideas and making personal sense of them.

According to Hofstein (2016), laboratory activity (practical work) is contrived learning experiences in which students interact with materials to observe phenomena. These experiences may have different levels of structure specified by teachers or laboratory handbooks (manuals) and may include phases of planning and design, analysis, and interpretation as the central performance phase.

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According to Woolnough (2019), care should be taken because it is not just enough for students to do something in the laboratory but rather laboratory experiences need to be designed so that they focus attention. He also notes that in many countries, over the last few decades, science has been taught in part involving students in teacher guided, activity-based lessons. Through such activities, students are expected to develop their investigatory skills and through their results of experimentation to develop sound scientific knowledge.

Ausubel (2018), observes that the laboratory gives the students appreciation of the spirits and the method of science, promotes problem solving, analytic and generalisation ability, provide the students with some understanding of the nature of science. Woolnough and Allsop (2015) stresses that if we want the students to acquire skills that are used by practicing scientists and if we are concerned with the teaching of the process skills of science, practical work seems to be vital in this context. Levinson (2014) cautions that practical work activity should not be a sit and watch demonstration or a recipe practical because such do not promote intellectual or cognitive skill development.

In a laboratory, numerous experiences may be provided in which students manipulate materials, gather data, make inferences, and communicate the results in a variety of ways (Tamir & Lunetta, 2018).

Studies have shown that students have different attitudes towards laboratory work; some enjoy it while others do not. Tasker (2018) found that secondary school students saw little connection between practical work classes and other science lessons. A mention of science lessons to students and they think of laboratories, some do it with delight, others with lack of joy. After the First World War, the laboratory acquired a

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central role not just as a place for demonstration and confirmation but also as the core of the science learning process. According to Hofstein *et al.,* (2019), practical activities are central in science teaching. They enhance the achievement of objectives of science education (cognitive, psychomotor, and affective) (Hofstein, 2016). The practical skills are tested in chemistry paper three. The paper tests students'

(i) Ability to follow a set of instructions

(ii) Manipulative skills such as the ability to handle apparatus.

(iii) Ability to make accurate observations.

(iv) Ability to record observations accurately

(v)Ability to make accurate deductions (KNEC report, 2005).

According to Cartnell (2015), practical work in chemistry may be divided into several types as shown below:

1. Experiments done by students.
2. Experiments shown directly to students.
3. Experiments shown indirectly to students by the use of some kind of visual aid.
4. Experiments which are merely described, either verbally or in writing by the teacher or in a book.

It is assumed that the order of priority at school level is 1 >2 > 3> 4 and that only a few experiments come into category four. At tertiary level, categories one and four are predominant. In addition, it also seems clear that, in order for experimental work in chemistry to be productive, it should include several currently accepted reasons:

i. To develop observational, manipulative, preparative and instrumental skills.
ii. To acquire, illustrate and amplify chemical knowledge.
iii. To recognise the precision and limitation of laboratory work

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iv. To record accurately and communicate results clearly.

v. To develop personal responsibility and reliability in conducting experiments.

vi. To plan and carryout further laboratory work by the effective use of available laboratory resources (Miller, 2018).

Apparatus used in the laboratories are becoming more advanced and expensive such as computers. This is inevitable if science must keep pace with technology as the two are symbiotic (Clarke, 1985). Even the less glamorous apparatus in the laboratory is becoming more expensive. This has led to more improvisation, both by the students and teachers. According to Lewis (2012), practical work enhances learning by allowing students to work together in groups hence discussing among themselves in a language familiar to all. Practical work supports the general aims of education such as creativity, autonomy, self-confidence, heightening of interests and enjoyment of learning.

2.4 Skills taught in the laboratory.

The skills taught in chemistry are the same as those taught in science education. Science education is the field concerned with sharing science content and process with individuals not traditionally considered part of scientific community. The target individuals may be children, college students or adults within the public. The world of science education comprises science content, some social science, and some teaching pedagogy (Duit, 2006). According to Twoli (2006), skills taught in the chemistry laboratory are practical skills. The skills are of two types namely, manipulative skills and process skills.

2.4.1 Manipulative Skills

Manipulative skills are also known as motor skills. The skills deal with the ability to handle and arrange apparatus and materials for proper experimentation (Twoli, 2006).

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If students have proper manipulative skills, they will make accurate observations and record the data collected accurately. This will then translate to accurate interpretation. Manipulative skills include handling, arranging, fixing, pouring, heating, filtering, and weighing.

2.4.2 Process Skills

The science process skills are tools that students use to investigate the world around them and to construct science concepts (Yockey, 2001). They are a means to learning and are essential to the conduct of science. Process skills are more cognitive in nature (Twoli, 2006). Jenkins (1985) gave the following as the main process skills which should be emphasised in any science practical session. They include observing, classifying, measuring, communicating, inferring, predicting, interpreting, experimenting skills, comparing, contrasting, organising and analysing. The skills are not just useful in science but in any situation that requires critical thinking. The process skills are integrated when scientists design and carry out experiments or in everyday life when we all carry out fair test experiments. All the skills are important individually as well as when they are integrated.

2.4.3 Observing skills

Observing is the fundamental science process skill (Rabacal, 2016). Observing refers to the properties of objects and situations using the five senses of seeing, hearing, touching, smelling, and tasting. An observation is simply a record of sensory experience made using the five senses. Scientists use observations skills in collecting data. The ability to make good observations is also essential to the development of other science process skills (Yockey, 2001). The simplest observations made using the senses are qualitative such as the colour of a precipitate or the temperature of a solution. Others are quantitative and involve numbers or quantity such as the mass of a solid.

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2.4.4 Classifying skills

Classifying is relating objects and events according to their attributes (Michael et al, 2014). Places, objects, ideas, and events may be classified. It involves grouping objects like categories. Items can be classified at many different levels, from the very general to the very specific.

2.4.5 Measuring skills

To measure is to express the amount of an object or substance in quantitative terms or comparing an object to a standard (Hofstein, 2012). It is the process of making observations that can be stated in numerical terms. Examples of measurement include length in meters, volume in liters, mass in grams, force in Newton and temperature in degrees Celsius. All measurements should be given in SI units.

2.4.6 Communicating skills

Communicating is the process of describing, recording, and reporting experimental procedures and results to others. It is a way of sharing information with others. It represents observations, ideas, theoretical models, or conclusions by talking, writing, drawing or making physical models (Michael, 2014). Communication may be oral, written or mathematical. Communication skills enable one to organise ideas using appropriate vocabulary, graphs, other visual representations, and mathematical equations. An example is describing the relationship between melting time for an ice cube and amount of salt sprinkled on the cube by writing about it or by constructing a graph. Communication is essential in science due to its collaborative nature.

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2.4.7 Inferring skills

According to Wellington (2017), to infer is to explain a particular object or event. It is a process of drawing conclusions based on reasoning or experience. Inferring also has got to do with interpretation of information.

2.4.8 Predicting skills

Predicting is forecasting a future occurrence based on past observations or on the extension of data. It is the process of stating in advance the expected results of tested hypothesis. A prediction that is accurate tends to support the hypothesis and can be used in planning a test of that hypothesis (Yockey, 2001).

2.4.9 Interpreting skills

Interpreting refers to considering evidence, evaluating and drawing conclusions by assessing the data. It is answering, the question, “what do your findings tell you?” Put in other words, it is giving explanations, inferences or hypothesis from data that have been placed in data table or graph (Wellington, 2017).

2.4.10 Experimenting skills

Experimenting is testing a hypothesis through manipulation and control of independent variables and noting the effect on dependent variables. It involves interpreting and presenting results in the form of a report that others can follow to replicate the experiment. Experimenting is an integrated process skill (Yockey, 2001).

2.4.11 Recording skills

According to Tsai (2013), Chemistry lab skills like keeping lab logs and producing research papers are crucial. Typically, written reports are the primary form of communication among scientists. So, after receiving experiment results, the first step is to capture the data. Good records are a useful tool for management. They are helpful

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for gathering information, looking into errors, and analysing issues (Kipnis & Hofstein, 2018). The results may be continuously monitored by keeping these records. We ought to publish it after thoroughly validating these results. These studies are often published in a few science publications. The development of scientific writing skills is crucial for that.

2.4.12 Comparing skills

Comparing involves assessing different objects, events or outcomes for similarities. This skill allows students to recognise any commonality that exists between seemingly different situations. A comparison skill to comparing is contrasting in which objects, events or outcomes are evaluated according to their differences (Michael et al, 2014).

2.4.13 Contrasting Skills

Jenkins (2015) explains that Contrasting involves evaluating the ways in which objects or outcomes are different. It is a way of finding subtle differences between otherwise similar objects, events, or outcomes.

2.4.14 Organising Skills

Organising is the process of arranging data into a logical order so that the information is easier to analyses and understand. The organising process includes sequencing, grouping and classifying data by making tables and charts, plotting graphs and labeling diagrams (Wellington, 2017).

2.4.15 Analysing Skills

The ability to analyses is critical in science. Students use analysis to determine relationship between events, to identify the separate components of a system to diagnose causes and to determine the reliability of data (Hofstein, 2018).

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2.5 Methods and Strategies of Teaching Chemistry

There are two main teaching strategies or teaching approaches. A strategy is a way and means of carrying out teaching. The two teaching strategies are;

i. Expository
ii. Heuristic

2.5.1 Expository Strategy

These are methods that assume learners as passive recipients of information while the teacher is considered as the overall giver of knowledge (Masferrer *et al.*, 2019). Expository strategies are teacher talking kind of teaching. If any practical is involved, it is usually done by the teachers through demonstrations. Expository methods are also referred to as traditional methods. They are not common in the teaching of chemistry.

2.5.2 Heuristic strategy

Masferrer *et al.*, (2019) defines heuristic approach as methods which involve the attitude of the discoverer. Such methods involve the learners in finding out instead of being merely told about things. The students get involved in:

i. Search for scientific data.

ii. Development of process skills such as ability to make conversations, perform experiments, collect data, make deductions and present the results, handling apparatus and using them for data collection, discuss procedures and observations amongst themselves. Heuristic approaches in chemistry include methods such as problem solving, project work and laboratory experiments. The methods require a vast range of resources (Dale, 2016). Dale gave the cone of experience. The cone relates teaching strategies to resources. The top of the cone has the abstract strategies that are more teachers centered and require fewer resources while at the bottom are the learner

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centered strategies that allow for greater autonomy of the learner and require more resources. The top of the cone begins with verbal symbols and at the bottom there is the direct purposeful experience such as student working with apparatus and chemicals in the laboratory.

2.6 Determinants of Teaching Methods

According to Ong'amo *et al.,* (2015), the learner, the learning objectives and the resources available are the main determinants of a teaching method. Das (2015) indicates that in choosing the method of teaching science, the teacher should consider the objectives to be achieved, the learner and nature of content to be taught. The science teacher should be acquitted with the use of a variety of methods and procedures of teaching science. Twoli *et al*., (2007), observes that there is usually nothing like a better method. If one makes a good choice and prepares well, almost any method is a good method. However, since chemistry is a practical subject, hands-on activities are of paramount importance. Eshiwani (2014), notes that the teaching methods in science have for a long time been geared towards the pursuit of knowledge per se and due to such an approach, the teachers are more concerned with the theoretical approach rather than the practical approach. Resources seem to be a limiting factor in the choice of teaching method. Kyalo (2014) noted that teachers disregarded improvising apparatus and hence the lack of appropriate apparatus hinders effective science teaching. Das (2015) recommended that since science is a practical subject, children should be exposed to the practical aspects of science. However, the teaching resource requirements for science have always been an issue in terms of their provision to schools.

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2.7 Methods of Teaching Chemistry

2.7.1 Lecture Method

The method is very expository in nature. Research in education shows that lecture method is used quite a lot (Ornstein, 2015). He defined lecture as a didactic instructional method involving one-way communication from the active presenter (teacher) to the mere or less passive audience (learners). According to Twoli *et al.,* (2007) lectures can be in the form of formal lecture, informal lecture or brief lecture. A formal lecture is a lecture which lasts for most of the entire lessons. The students' questions and comments are limited. Such lectures are not recommended in schools. Informal lectures last between five and ten minutes. They are filled with students' responses, questions or watching visual aids. They are recommended for use in secondary schools. Brief lectures last not more than five minutes. They are used for introducing, summarising, explaining, or describing an object or procedure. Das (2015) gave the following as the limitations of lecture method.

a) Content is easily forgotten because the method encourages memorisation of facts. It does not utilise all the senses but only the auditory.

b) It does not offer training for the attainment of scientific skills. The method ignores experimentation which is the basis of modern scientific knowledge, and the scientific skills are mainly attained by experiment.

c) Lectures can also be boring if lengthy and if the teacher lacks appropriate skill to keep the lesson interesting and retain the learners' attention.

2.7.2 Demonstration Method

Dale (2016) defines demonstration as a visualised explanation of an important idea or process. The demonstration shows how certain things are done. He further notes that

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demonstration may require nothing further than observation-accurate observation. Teacher demonstrations are quite common in the sciences, and these are usually held in the laboratories. Washton (2014), indicates those demonstrations are frequently used to illustrate, clarify and amplify a scientific concept or principle. Demonstrations should provide opportunities to pupils to make careful observations in order that they can make deductive references. Like any other method of teaching science, it is combined with other methods of teaching such as discussion. A demonstration can either be done by a teacher or a student. If the purpose of demonstration is to show, verify or illustrate a clear-cut scientific principle, the teacher should perform the demonstration. It may be desirable to have some demonstrations performed by students to encourage interest and to stimulate further learning in science through experimentation and further studies. (Washton, 2014). According to Twoli *et al*., (2007), the following are situations when demonstrations will be preferred.

(i) When the experiment is dangerous e.g., preparation of poisonous gases

(ii) When the equipment is expensive and complicated for learners

(iii) When the resources are limited

(iv) When time is limited

(v) Showing a difficult skill among others.

A demonstration encourages interest and stimulates further learning in science through experimentation and further study. Demonstration can be an active and economical method of developing concepts (cognitive). However, the teacher should involve students during demonstration because their involvement enhances the ability to take charge of their own learning (Millar, 2004).

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2.7.3 Laboratory Experiments

The method provides the learners with a direct purposeful experience. Dale (2016) defines direct purposeful experience as something you can get your hands on or something you can sink your teeth into. Twoli *et al*., (2007), note that the learning is arranged to perform some special tasks by manipulating the materials and apparatus under the direction of the teacher. In most schools' learners work in groups of two, three or more. Laboratory experiments have the main advantage of giving a chance to learner to practice manipulative and process skills. The role of the teacher is to facilitate laboratory experiments. Shulman and Tamir (2013), proposed and gave the role of laboratory experience in science education as to arouse and maintain interest, attitude satisfaction, open mindedness and curiosity in science, to develop creative thinking and problem solving, to promote aspect of scientific thinking and to develop practical abilities. The laboratory experiments should be integrated with other facilities. Ausubel (2018) notes that the laboratory should be carefully integrated with the textbook, that is, it should deal with the methodology related to the subject matter of the course and not with the experiments chosen solely because of their sustainability for illustrating various strategies of discovery.

2.8 Fieldwork and Project Work

There is increased use of fieldwork where students go to see science or chemistry being practiced in real life and in its natural setting, (Woolnough & Alsopp, 2015). This has led to what is often called zero-cost science. In addition, it helps in lowering costs. Fieldwork motivates students to make more realistic career choices. It also helps to demystify chemistry; it's no longer seen as alien and unintelligible. Fieldwork in secondary schools mainly involves visiting industries and other places where chemistry knowledge is applied. Closely associated with fieldwork is project work. Project work

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is when students take an extended and independent or group of practical work (Twoli, 2006). Project work has often been confused with laboratory practical work. The difference is that in project work students do different manipulated activities or varied library search or different problem-solving tasks independently on individual or group basis while in laboratory work students usually do the same practical in the same place at the same time with the direct supervision of the teacher. Projects in chemistry can be observational or surveyed (Twoli, 2006). Project work leads to increased interest and relevance in the learning of chemistry.

2.9 Utilisation of Laboratory Resources

Utilisation of science laboratory equipment refers to the number of times that the available science laboratory equipment is used during classes or laboratory practical lessons. According to Lawal (2013), laboratory equipment influences practical learning, making the classroom real, lively, and more meaningful. They have the potential of making the content learnt permanent and consequently increase students' performance. Utilisation of science laboratory equipment increases the chances of learners' concentration and acquisition of practical skills. In effect, acquisition of such skills enables students to be innovative, discover new ideas and capable of combating unemployment and poverty. Students should therefore make maximum use of such equipment to reap their immense benefits. Oluwasegun *et al.,* (2015) examined the impact of physics laboratory equipment on students taking physics in Ethiopia West local government area. From the study it was discovered that students' performance in physics was greatly improved by availability of physics laboratory equipment.

These arguments are in consonance with those of Olufunke (2012) that high levels of availability and utilisation of chemistry laboratory equipment has a significant relationship with students' academic performance. In his study, Olufunke (2012)

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revealed that schools with the highest utilisation frequency of laboratory equipment recorded high mean scores in students' academic performance and vice versa. At the same time average mean scores in students' academic performance were recorded in schools with average utilisation frequency of science laboratory equipment. This can therefore be concluded that high student mean scores in science subjects are attributed by high frequencies in utilisation of science laboratory equipment during the teaching and learning process.

2.10 Common Challenges of Chemistry Laboratory Practice

Teaching and learning process of laboratory practical in chemistry is not an easy task. For one thing, the misconceptions of students in chemistry retards their energy; on the other hand, lack of laboratory experience, exposure and chemistry process skills hinders students from attaining the objectives of laboratory practical designed.

Bailey (2021) explained in their study that although chemistry laboratory practices enhance the students' learning experience in the chemistry field, it has also been criticised for the fact that it is unproductive and confusing unless clear thought used. It was suggested that cultivation of students' intellectual skills should be given attention to enhance learning rather than following *"cookbook" approach*. Hence poorly involved and experienced students developed poor or no experience of laboratory management even for highly expensive chemicals and apparatus (Temechegn, 2011). This is common especially in college that students' involvement for practical manipulation of these substances is rare in laboratory. This is due to lack of well-organised laboratory, large class size, students' science background, proximity of practical and theoretical class, availability of standardised laboratory books and poor skills of application of IT for laboratory practical (Laverman *et al.*, 2005).

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Empirically, Tekalign (2016), undertook a study on science laboratory equipment in the teaching of science subjects in Ethiopia. The findings of the study disclosed that, 33.33% of the high schools involved in the study did not have science laboratories completely despite them forming a compulsory component for teaching practical activities. The rest of the high schools in the zone under study were poorly equipped. The findings disclosed further that, only two (16.67%) of the high schools in Ilu Abba Bora Zone were sufficiently equipped with science laboratory resources required in the teaching of chemistry practical lessons. In the same study, only five high schools under study had adequate chemistry laboratory equipment while only three of the high schools had adequate physics laboratory equipment as the rest were poorly equipped.

The unavailability and inadequacy of science laboratory resources in the schools makes it difficult for teachers and students to cover areas that require practical activities which leads to non-attainment of the curriculum objectives. chemistry laboratory equipment is crucial in the teaching of science chemistry without which the subjects lose their value, a preventive implication from pursuing Chemistry and allied courses in higher institutions. It is therefore very crucial to teach basic science practically to promote critical thinking, objectivity and rationality which science entails. The laboratory practical is one of the most effective experiences geared towards the development of scientific skills in students (Tekalign, 2016).

In South Africa, Zenda (2016) carried out a study to investigate the factors associated with low grade achievement in Physical Sciences among secondary school students in the rural area of Limpopo. According to the results of the findings, the following revelations were prominent; Inadequacy of teaching and learning resources, low student motivation, high pupil teacher ratio and high teaching workload. According to the study all these contributed to the low students' achievement grades.

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Chemistry is a difficult subject to teach, especially in rural areas. Most teachers believe that lack of access to resources and equipment to teach chemistry is a major obstacle to effective teaching (Laidlaw *et al*., 2009). The unavailability of resources in schools restricts teachers' ability to be effective in facilitating teaching and learning process. The provision of an enriching educational experience relies on adequate resources in schools, such as science materials and equipment. Making teaching and learning materials accessible is recognised as vital in providing better learning opportunities to students. The scarcity of resources has a negative influence on the quality of education in schools. Inadequate practical resources for teaching and learning chemistry usually results in teachers having a less positive impact on student's development (Lingam & Lingam, 2013).

2.11 Summary and Research Gap

Literature reviewed for this study has clearly illustrated the importance of chemistry laboratory in teaching and learning of chemistry. Since chemistry is a practically oriented subject, it is anticipated that most of the practical experiences can best be given in the laboratory (Nderitu, 2019). According to Hofstein (2019), laboratory activity (practical work) is contrived learning experiences in which students interact with materials to observe phenomena. Similarly, Ausubel (2018), observes that the laboratory gives the students appreciations of the spirits and the method of science, promotes problem solving, analytic and generalisation ability, provide the students with some understanding of the nature of science. Woolnough and Allsop (2015) also stress that if we want the students to acquire skills that are used by practicing scientists and if we are concerned with the teaching of the process skills of science, practical work seems to be vital in this context. Woolnough (2019), insists that care should be taken in

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the process because it is not just enough for students to do something in the laboratory but rather laboratory experiences need to be designed so that they focus attention.

Thus, chemistry laboratories should be well equipped and utilised in teaching and learning to enable students who complete secondary school education graduate with requisite knowledge and skills that would not only enable them to compete favorably in the job market but also pursue science and technology related fields. This could be attributed to the fact that the reviewed literature has shown that the main role of a chemistry laboratory is to enable students to develop and practice manipulative skills (Twoli, 2007). However, the review also showed that there is limited empirical data on extent and influence of the use of chemistry in the teaching and learning of chemistry in the country in general and in Akuapem South Municipality which raises the need for the study.

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CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter concentrates on the methods employed for successful gathering of data. Specifically, the chapter presents the location of the study, study design, population, sample and sampling procedures, research instruments, validity and reliability of the instruments, data collection procedures, data analysis and ethical considerations of the study.

3.1 Location of the Study

The study was carried out in the Akwapim South District (figure 2). The district is one of the recently created districts in the Eastern Region of Ghana. It was established on 6th February 2012 by an Act of Parliament (Legislative Instrument 2040). The district is carved out from the old Akwapim South Municipality. The district has Aburi as the capital, and it is about 20 km from Accra, the national capital and has a population of 37,501. This chapter gives a brief description of the district in terms of the physical features, cultural, economic, and social structure. It also discusses census methodology, concepts and definitions and the organisation of the report.

The Akwapim South District is located at the southeastern part of the Eastern Region of Ghana between latitudes 5.450N and 5.580N, and Longitudes 0.0W (figure 2) and covers a land area of about 224.13 kilometres square. It is bordered to the west by the Nsawam-Adoagyiri Municipality, to the south-east by the Kpone-Katamanso District, to the south by the Ga East District and to the North-East by the Akwapim North Municipality.

The population of Akwapim South District, according to the 2010 Population and Housing Census, is 37,501 representing 1.4 percent of the region's total population.

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Males constitute 48.5 percent and females represent 51.5 percent. About three-quarters (73.4%) of the district's population lives in the rural areas and has a sex ratio of 94 males to a hundred females. About two-fifths (40.1%) of the population of the district is youthful (0-14 years) depicting a broad base population pyramid which tapers off with a small number of elderly persons (5.9%). The total age dependency ratio for the district is 76.7, and males have a higher dependency ratio of 81.6 compared to females who has a dependency ratio of 72.4.

Of the population 11 years and above, 86.2 percent are literate, and 13.8 percent are not literate. The proportion of literate males (50.7%) is slightly higher than that of females (49.3%). Almost seven out of ten people (64.7%) indicated they could read and write both English and Ghanaian language. Of the population 3 years and above in the district, 13.1 percent have never attended school, 39.8 percent are currently attending, and 47.2 percent have attended in the past.

The district is predominantly Akwapims, who are part of the Akan ethnic group. The main dialect in the district is Akwapim Twi. There are other ethnic groups who have migrated to settle in the district, and these include Ewes, Gas and Hausas. It needs to be stressed that the spillover of the population of the Accra Metropolitan Area because of intense urbanisation as well as the extensive sprawl are reconfiguring the population dynamics within the Akwapim South District, especially around its capital, Aburi and its environs. This process is likely to produce a more heterogeneous population in the district soon.

Traditionally, the district is under the Okuapeman Traditional Council with the Okuapemhene as the Paramount Chief. The Chief of Aburi, who is the Adontenhene of the Akwapim Traditional Area is also the traditional head of the district, with many sub-chiefs under him. The major festival celebrated by the people of the district is the

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Odwira festival. It is celebrated in October every year. The matrilineal system of inheritance is practiced by the people of Akwapim.

MAP OF AKUAPEM SOUTH DISTRICT

Figure 2 Map of Akuapem South District

3.2 Research Design

Khalid, Abdullah and Kumar (2012) defined a research design as a plan, structure, and strategy of investigation to obtain answers to research questions or problems, while

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(Hanson *et al*., 2005) defined it as the blueprint for collection, measurement, and analysis of data.

The study used a descriptive survey research design. This design is used to explain the availability and utilisation of chemistry laboratory resources for teaching and learning in the second cycle institutions in the Akuapem South Municipality in the Eastern Region of Ghana.

The descriptive research design involves description of the dependent variable in the context of the independent variable. Descriptive studies are typically structured with clearly stated hypotheses or investigative questions (Sundeep, 2007). The major goal of such formal research design is to answer the research questions posed.

The study used a quantitative data gathering strategy to examine the topic under investigation. Quantitative research yields numerical information or data that can be turned into numbers. It focuses more on counting and classifying features and constructing statistical models and figures to explain what is observed (Sampson & Walker, 2012). The purpose is to quantify data and generalise results from a sample to the population of interest. It involves the use of structured techniques such as questionnaires or interview (Hanson *et al*., 2005).

3.3 Population

Research population refers to or represents all the cases of people, organisations or institutions of interest to the researcher (Kothari, 2004). According to Mugenda and Mugenda (2003), a population refers to an entire group of individuals, objects or events having a common observable characteristic of the researcher's interest. The population is the group of individuals to which the findings, discussion of the findings, and the implications of the research are generalised (Sampson & Walker, 2012). That is, the

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population possesses certain characteristics or information relevant to the research or researcher.

The target population for the study consists of chemistry teachers, headteachers and science students in the second cycle institutions in the Akuapem South District. The targeted population numbered 170 chemistry students and 30 chemistry teachers whereas the accessible population numbered 85 chemistry students and 15 chemistry teachers.

3.4 Sample Size and Sampling Techniques

Sample size could be explained as the suitable number of participants required to attain the desired study results (Bryman, 2003). One hundred participants 100 (50%) of the accessible population were selected for the study. Purposive sampling technique was used to select the respondent. The purposive sampling method was used because it allowed the study to focus on people who would most likely have experience and know about laboratory activities. Stone-Romero (2002) explains purposive sampling as a type of non-probability sampling, which is characterised using judgment and a deliberate effort to obtain representative samples by including typical areas or groups in the sample. The importance of purposive sampling lies in selecting information rich cases, for in-depth analysis related to the central issues being studied.

3.5 Instruments

Structured questionnaire was used to collect primary data. Questionnaire, according to Saunders, Lewis and Thornhill, (2003) is one of the most common data collection techniques, and it is a device for obtaining responses to a predesigned subject matter using a form that the respondent fills out. The survey included both closed-ended and open-ended items, with closed-ended items presenting respondents with a limited range

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of alternatives and open-ended items encouraging them to disclose as much information as possible. These questionnaires provided the researcher with data on the subject.

3.6 Validity of Instrument

Validity is the degree to which the study accurately answers the questions it is intended to answer (Gravetter & Forzano, 2018). One way the researcher ensured validity was by employing the expertise of colleagues who are also first year MPhil students and the supervisor. Vanderstoep and Johnson (2008) argued that a researcher can ensure validity by asking a group of experts to review instruments. Further, draft copies of instrument were sent to some lecturers from the chemistry department who read through and made the necessary corrections. After this review, the questionnaires were again sent to the researcher's supervisor for further review. Their professional advice helped shape the instrument, hence ensuring face and content validities of the instruments.

3.7 Reliability of Instrument

Reliability is the consistency of test instruments across samples selected repeatedly (Webb *et al.*, 2006). To ensure reliability of the study, a pilot study was carried out in the Okere District. This district was selected because of its similar characteristics with the district selected for the actual study. After the pilot study, unclear questions were modified, and wrong phrasings of questions were rephrased to fit the study. Ambiguous questions were also detected and corrected according to their advice. All these were done to ascertain the level of suitability of the instruments used, ease understanding and maximise their reliability. Cronbach's reliability coefficient of 0.791 was obtained for the instrument.

3.8 Data Collection Procedures

The researcher was given a research authorisation letter and an introduction letter by the school authorising the researcher to proceed with data collection. With these letters

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the researcher sought a research permit from the District Education Director-Akuapem South District. The researcher then visited the heads of the Adonten SHS, Diaspora Girls SHS, Aburi Girls SHS, and Aburi Presbyterian SHS, introduced herself with the available letters and sought the permission of the heads to reach the teachers to administer the questionnaires. Necessary arrangements concerning days and time were made with the heads of the respective schools.

On the data collection day, the researcher sampled the respondents according to the sampling technique adopted. The respondents were then requested to fill in the questionnaires and the researcher collected them.

3.9 Data Analysis

The researcher edited, tabulated, and analysed the data collected using the Statistical Package for Social Science (SPSS) version 23.0, and transferred these statistical data into statistical chart such as Pie charts and Bar charts using Microsoft Word and Excel software.

3.10 Ethical Consideration

Neuman (2014) posits that ethical issues tell what is not legitimate to do or what a moral research procedure involves. Ethical principles have it that, a researcher must have respect for human beings, beneficence, there must be research merit and integrity as well as justice (Australian Council for International Development, 2017). Favaretto *et al.,* (2020) also discussed that, the principles of ethics are minimising the risk of harm, obtaining informed consent, protecting anonymity and confidentiality, avoiding deceptive practices and providing the right to withdraw.

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The researcher appropriately addressed ethical issues with regards to the approach adopted. An introductory letter of permission to carry out the study was obtained from the Department of Science, University of Education, Winneba.

The purpose and objectives of the study were concisely explained to the target respondents. The participants were assured of confidentiality of their responses. Respondents were only involved after their informed consent was obtained. They were again notified that their involvement will not have anything to do with their job evaluation. Finally, it was emphasised that their responses were voluntary.

In summary, the researcher considered the following ethics to ensure a smooth gathering of data

(i) An introductory letter granting permission to embark on the study was collected from the Department of Science and was shown to the participants to underline the authenticity and genuineness of the study.

(ii) Names of respondents were not required.

(iii) Gathered information was only used for academic purposes and was treated with utmost confidentiality.

(iv) All respondents were assured of their anonymity.

(v) Again, participation was voluntary.

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CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

This chapter provides the various findings of the research objectives for the study, and this is followed by systematic discussion for each of these results. The chapter is a representation of the analysed data based on the data collected from the study area.

Section A

4.1 Personal Information of Respondents

The biography of the respondents is represented in tables below. In Table 1, the gender of the respondents in the study are indicated.

Table 1: Gender of respondents (Teachers and Students)

Sex	No. of respondents	Percentage (%)
Teachers	**15**	**15 (100)**
Male	10	10(66.67)
Female	5	5 (33.33)
Students	**85**	**85 (100)**
Male	35	35 (41.18)
Female	50	50 (58.82)
Total	**100**	**100**

Source: field data (November, 2022)

According to the Table 1, out of the 15 teachers who responded to the questionnaire, 5 were female, accounting for 33.33% of the total teachers. On the other hand, only 10 male teachers participated, representing 66.67% of the total teachers. Regarding the students, a total of 85 respondents took part in the study. Among them, 50 were female

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students, comprising 58.82% of the total students. The remaining 35 respondents were male students, accounting for 41.18% of the total students.

it is evident that Aburi Girls' High and Diaspora Girls' High School have a higher representation of female teachers and students. This observation indicates that there were more female respondents compared to males in the research study. The table provided (Table 1) presents the gender distribution of the respondents, both teachers and students.

The data suggests that the research sample had a higher proportion of female respondents compared to males, in terms of students. It is worth noting that the lower participation of male respondents was attributed to their perceived busyness or lack of readiness to respond to the questionnaire, as mentioned in the research. In addition, many of the respondents involved were between the ages of 15-20 years. This was because the students outnumbered the teachers.

How long teachers have taught in their schools are captured Table 2

Table 2: How long teachers have taught in GES.

Working years	No. of respondents	Percentage (%)
1—5 years	3	20
6-10 years	5	33.33
11-15 years	2	13.33
16-20 years	2	13.33
21-25 years	1	6.67
26-30 years	1	6.67
Above 30 years	1	6.67
Total	**15**	**100**

Source: field data (November, 2022)

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According to Table 2, which shows the number of respondents and the percentage of teachers based on their years of teaching in the Ghana Education Service (GES), several observations can be made.

Among the 15 respondents, most teachers had been teaching for a relatively short period. Specifically, 3 teachers (20% of the respondents) reported having taught for 1-5 years, while 5 teachers (33.33% of the respondents) had 6-10 years of teaching experience. This suggests that a significant portion of the teachers in the sample were relatively early in their teaching careers.

In contrast, there were fewer respondents with longer tenures. Two teachers (13.33% each) reported having taught for 11-15 years and 16-20 years, respectively. One teacher (6.67% of the respondents) fell into each of the following categories: 21-25 years, 26-30 years, and above 30 years of teaching experience.

The data provides insights into the distribution of teaching experience among the sampled teachers. The concentration of respondents with fewer years of teaching suggests a relatively young teaching workforce in the GES. This may have implications for the level of experience and expertise available among teachers, which could impact various aspects of education, including communication between healthcare professionals and patients.

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The qualification of teachers considered in this study are shown under Table 3

Table 3: Academic Qualification of Teachers

Qualification	No. of respondents	Percentage (%)
1st Degree	4	26.67
Masters'	3	20
Msc.	3	20
Mphil	2	13.33
PhD	2	13.33
Others	1	6.67
Total	**15**	**100**

Source: field data (November, 2022)

Table 3 presents the academic qualifications of the teachers involved in the study. A total of 15 respondents participated, and their qualifications were categorized into different levels. The table provides insights into the distribution and percentages of teachers with specific academic qualifications.

Among the respondents, 26.67% held a 1st Degree qualification, indicating that a considerable proportion of the teachers possessed an undergraduate degree. This suggests a solid foundation of formal education in the teaching profession.

The second most common qualification was a Masters degree, with 20% of the respondents having attained this level of education. Similarly, the category of "Msc" also accounted for 20% of the respondents. These findings indicate that a significant proportion of teachers had pursued advanced studies beyond the undergraduate level, thereby enhancing their subject matter expertise and pedagogical skills.

A smaller proportion of respondents, comprising 13.33% each, held an MPhil (Master of Philosophy) or a PhD (Doctor of Philosophy) qualification. These higher academic qualifications reflect a higher level of specialization and expertise among a subset of the teachers.

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One respondent (6.67%) had qualifications categorised as "Others," indicating a qualification outside the listed categories. This included specialised certifications, diplomas, or other non-traditional qualifications.

Overall, the data suggests a diverse range of academic qualifications among the teachers. The presence of teachers with postgraduate qualifications, including Masters, Msc, MPhil, and PhD, indicates a commitment to ongoing professional development and a potential for higher levels of subject knowledge and teaching effectiveness.

The findings from this analysis highlight the educational background of the teachers involved in the study, providing insight into their qualifications and potential expertise in the field of education.

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Section B

4.2 Chemistry Laboratory Facilities available for Senior High Schools

Research Question 1

What are the chemistry laboratory facilities available in the Senior High Schools in the Akuapem South Municipality for teaching and learning?

Table 4: Availability and adequacy of Chemistry apparatus in the Laboratory

APPARATUS	**RESPONSES (%)**						
	AA	**RA**	**NA**	**Total**	**ADEQUACY**		**Total**
					A	**NAd**	
Burette	55(55%)	15(15%)	35(35%)	100(100%)	40(40%)	60(60%)	100(100%)
Pipette	50(50%)	30(30%)	20(20%)	100(100%)	45(45%)	55(55%)	100(100%)
Conical flask	45(45%)	35(35%)	20(20%)	100(100%)	45(45%)	55(55%)	100(100%)
Funnel (Plastic/Glass)	50(50%)	40(40%)	10(10%)	100(100%)	55(55%)	45(45%)	100(100%)
Reagent Bottles	40(40%)	25(25%)	35(35%)	100(100%)	40(40%)	60(60%)	100(100%)
Beakers (Plastic/Glass)	60(60%)	20(20%)	20(20%)	100(100%)	45(45%)	55(55%)	100(100%)
Porcelian Tile	25(25%)	55(55%)	20(20%)	100(100%)	45(45%)	55(55%)	100(100%)
Gas jar	15(15%)	30(30%)	55(55%)	100(100%)	15(15%)	85(85%)	100(100%)
Measuring Cylinder	25(25%)	55(55%)	20(20%)	100(100%)	55(55%)	45(45%)	100(100%)
Volumetric Flask	25(25%)	45(45%)	30(30%)	100(100%)	50(50%)	50(50%)	100(100%)

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Weighing Bottles	15(15%)	45(45%)	40(40%)	100(100%)	30(30%)	70(70%)	100(100%)
Stirring Rod	15(15%)	35(35%)	50(50%)	100(100%)	25(25%)	75(75%)	100(100%)
Thermometers	25(25%)	40(40%)	35(35%)	100(100%)	35(35%)	65(65%)	100(100%)
Dropping pipette	45(45%)	40(40%)	15(15%)	100(100%)	60(60%)	40(40%)	100(100%)
Indicator Bottle	20(20%)	40(40%)	40(40%)	100(100%)	40(40%)	60(60%)	100(100%)

AA-Always Available, RA-Rarely Available, NA-Not Available A-Adequate, NAd-Not Adequate.

Source: field data (November, 2022)

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The results presented in Table 4 provide insights into the availability and adequacy of various chemistry laboratory apparatus. The findings based on the responses given by the respondents are discussed below

1. Burette:

• Availability: 55% of respondents indicated that the burette is always available (AA), 15% mentioned it is rarely available (RA), and 35% stated that it is not available (NA).

• Adequacy: 40% of respondents considered the supply of burette to be adequate, while 60% believed it to be inadequate.

2. Pipette:

• Availability: 50% of respondents reported that the pipette is always available (AA), 30% mentioned it is rarely available (RA), and 20% indicated that it is never available (NA).

• Adequacy: 45% of respondents considered the supply of pipette to be adequate, while 55% believed it to be inadequate.

3. Conical Flask:

• Availability: 45% of respondents stated that the conical flask is always available (AA), 35% mentioned it is rarely available (RA), and 20% reported that it is not available (NA).

• Adequacy: 45% of respondents considered the supply of conical flask to be adequate, while 55% believed it to be inadequate.

4. Funnel (Plastic/Glass):

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• Availability: 50% of respondents reported that the funnel is always available (AA), 40% mentioned it is rarely available (RA), and 10% indicated that it is not available (NA).

• Adequacy: 55% of respondents considered the supply of funnel to be adequate, while 45% believed it to be inadequate.

These results highlight the significant implications of inadequate apparatus availability on organising practical work in the chemistry laboratory. Limited availability of apparatus directly affects students' hands-on experience and their ability to engage in meaningful experiments. The findings suggest that even though certain apparatus, such as burettes and pipettes, are available to some extent, they are still considered inadequate by a significant percentage of respondents.

The implications of inadequate apparatus availability include: Reduced practical learning opportunities: Insufficient availability of apparatus restricts students' access to perform experiments, limiting their exposure to practical applications of theoretical concepts. This hampers their ability to develop laboratory skills and deepens their understanding of chemistry.

Hindered skill development: Practical work helps students develop crucial laboratory skills, such as equipment handling, following protocols, and making accurate observations. Inadequate apparatus availability limits students' opportunities to practice and refine these skills, impacting their overall skill development.

Incomplete understanding of chemistry: Practical work allows students to explore uncertainties and limitations inherent in experimental procedures, fostering critical thinking and problem-solving abilities. With limited apparatus availability, students

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may miss out on diverse experimental scenarios, leading to a less comprehensive understanding of chemistry.

The limitation of apparatus availability in chemistry laboratories can have a direct impact on students' hands-on experience and skill development. Practical work provides students with the opportunity to apply theoretical concepts in a real-world setting, develop essential laboratory skills, and deepen their understanding of chemical phenomena.

When there is a lack of necessary apparatus, students may not have access to the materials and tools required to perform specific experiments. This limitation restricts their ability to engage in hands-on activities and limits their exposure to various experimental techniques. As a result, students may miss out on valuable learning experiences that allow them to connect theory with practice.

Hands-on experience is crucial for students to develop laboratory skills such as proper handling of equipment, following experimental protocols, and making accurate observations. These skills are essential for future careers in scientific research, industry, or academia. Inadequate apparatus availability can hinder the development of these skills, leaving students with a gap in their practical knowledge and reducing their preparedness for future scientific endeavours.

Moreover, practical work allows students to explore the inherent uncertainties and limitations of experimental procedures, enhancing their critical thinking and problem-solving abilities. By encountering challenges and obstacles in the laboratory, students learn to troubleshoot, make adjustments, and analyse data critically. Inadequate apparatus availability limits the range of experiments that students can perform,

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limiting their exposure to different experimental scenarios and reducing their opportunities to develop these important skills.

Russell (2006) emphasises that meaningful hands-on experiences in chemistry education require access to a wide range of apparatus to ensure students can explore diverse experimental techniques and phenomena. Without such access, students may face a disconnect between theoretical knowledge and its practical application, resulting in a less comprehensive understanding of chemistry.

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The various tools that scientists use when working in a laboratory are referred to as equipment. Equipment is generally used to either perform an experiment or take measurements and gather data.

Table 5: Availability and adequacy of Chemistry Equipment in the Laboratory

					RESPONSES (%)		
EQUIPMENT	AA	RA	NA	TOTAL	ADEQUACY		Total
					A	NAd	
Retort Stands/Clamps	55(55%)	20(20%)	25(25%)	100(100%)	55(55%)	45(45%)	100(100%)
First Aid Box	15(15%)	35(35%)	50(50%)	100(100%)	20(20%)	80(80%)	100(100%)
Spatula	25(25%)	40(40%)	35(35%)	100(100%)	30(30%)	70(70%)	100(100%)
Test Tube Racks	45(45%)	25(25%)	30(30%)	100(100%)	55(55%)	45(45%)	100(100%)
Tripod Stands	20(20%)	45(45%)	35(35%)	100(100%)	40(40%)	60(60%)	100(100%)
Wash Bottles	55(55%)	25(25%)	20(20%)	100(100%)	60(60%)	40(40%)	100(100%)
Wire Gauze	25(25%)	35(35%)	40(40%)	100(100%)	45(45%)	55(55%)	100(100%)
Water Baths	10(10%)	35(35%)	55(55%)	100(100%)	20(20%)	80(80%)	100(100%)
Fume Chamber/Cupboards	15(15%)	25(25%)	60(60%)	100(100%)	20(20%)	80(80%)	100(100%)
Bunsen Burner	15(15%)	35(35%)	50(50%)	100(100%)	35(35%)	65(65%)	100(100%)
Filter Paper	20(20%)	45(45%)	35(35%)	100(100%)	30(30%)	70(70%)	100(100%)
Litmus Paper	15(15%)	55(55%)	30(30%)	100(100%)	35(35%)	65(65%)	100(100%)
Fire Extinguisher	30(30%)	40(40%)	30(30%)	100(100%)	50(50%)	50(50%)	100(100%)

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Cotton Wool	60(60%)	15(15%)	25(25%)	100(100%)	65(65%)	35(35%)	100(100%)
Chromatography Paper	10(10%)	25(25%)	65(65%)	100(100%)	20(20%)	80(80%)	100(100%)
Spring and Chemical Balance	15(15%)	55(55%)	30(30%)	100(100%)	40(40%)	60(60%)	100(100%)
Gas Supply	25(25%)	45(45%)	30(30%)	100(100%)	50(50%)	50(50%)	100(100%)
Preparatory Room	20(20%)	45(45 %)	35(35%)	100(100%)	45(45%)	55(55%)	100(100%)
Water Supply	50(50%)	30(30%)	20(20%)	100(100%)	50(50%)	50(50%)	100(100%)

AA-Always Available, RA-Rarely Available, NA-Not Available A-Adequate, NAd-Not Adequate.

Source: field data (November, 2022)

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Table 5 presents the availability and adequacy of various chemistry equipment in a laboratory. The responses are categorised as follows:

• AA (Always Available): The equipment is always available in the laboratory.

• RA (Rarely Available): The equipment is rarely available in the laboratory.

•NA (Not Available): The equipment is not available in the laboratory.

The table also provides the total number of responses for each equipment and calculates the adequacy of the equipment based on the responses.

the data presented in the table, let's examine

1. Retort Stands/Clamps:

Availability: 55% of the respondents stated that retort stands/clamps are always available, while 20% said they are rarely available, and 25% reported them as not available.

Adequacy: Among those who responded, 55% considered the availability of retort stands/clamps as adequate, while 45% found them inadequate.

2. First Aid Box:

Availability: 15% of the respondents stated that a first aid box is always available, 35% reported it as rarely available, and 50% mentioned it as not available.

Adequacy: Among those who responded, 20% considered the availability of a first aid box as adequate, while 80% found it inadequate.

3. Spatula:

Availability: 25% of the respondents stated that spatulas are always available, 40% reported them as rarely available, and 35% mentioned them as not available.

Adequacy: Among those who responded, 30% considered the availability of spatulas as adequate, while 70% found them inadequate.

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By examining the entire table, we can observe the availability and adequacy of various equipment in the laboratory. Some equipment, such as retort stands/clamps, test tube racks, wire gauze, and filter paper, appear to have a higher availability and adequacy compared to others. On the other hand, equipment like first aid boxes, spatulas, water baths, and fume chambers/cupboards seem to have lower availability and adequacy.

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The availability and adequacy of chemical salts were also surveyed. Table 5 displays the availability and adequacy of salts for teaching and learning chemistry in the laboratory.

Table 6: Availability and adequacy of Salts in the Chemistry Laboratory

SALTS	RESPONSES (%)						
	AA	RA	NA	Total	Adequacy		Total
					A	NAd	
Lead Nitrate	15(15%)	25(25%)	60(60%)	100(100%)	40(40%)	60(60%)	100(100%)
Aluminum Sulphate	35(35%)	35(35%)	30(30%)	100(100%)	30(30%)	70(70%)	100(100%)
Sodium Chloride	55(55%)	25(25%)	20(20%)	100(100%)	60(60%)	40(40%)	100(100%)
Aluminum Nitrate	25(25%)	50(50%)	25(25%)	100(100%)	30(30%)	70(70%)	100(100%)
Zinc Sulphate	25(25%)	40(40%)	35(35%)	100(100%)	45(45%)	55(55%)	100(100%)
Zinc Carbonate	20(20%)	40(40%)	40(40%)	100(100%)	25(25%)	75(75%)	100(100%)
Barium Chloride	10(10%)	40(40%)	50(50%)	100(100%)	50(50%)	50(50%)	100(100%)
Magnesium Carbonate	10(10%)	45(45%)	45(45%)	100(100%)	20(20%)	80(80%)	100(100%)
Magnesium Sulphate	15(10%)	45(45%)	40(40%)	100(100%)	15(15%)	85(85%)	100(100%)
Ammonium Carbonate	15(15%)	35(35%)	50(50%)	100(100%)	20(20%)	80(80%)	100(100%)
Ammonium Sulphate	25(25%)	35(35%)	40(40%)	100(100%)	20(20%)	80(80%)	100(100%)
Ammonium Chloride	10(10%)	55(55%)	35(30%)	100(100%)	30(30%)	70(70%)	100(100%)
Copper Sulphate	40(40%)	35(35%)	25(25%)	100(100%)	35(35%)	65(65%)	100(100%)

AA-Always Available, RA-Rarely Available, NA-Not Available A-Adequate, NAd-Not Adequate.

Source: Field Data (November 2022)

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Table 6 presents the availability and adequacy of different salts in a chemistry laboratory. The responses are categorised as follows:

• AA (Always Available): Salt is always available in the laboratory.

• RA (Rarely Available): salt is rarely available in the laboratory.

• NA (Not Available): salt is not available in the laboratory.

Table 5 also provides the total number of responses for each salt and calculates the adequacy of the salt based on the responses. From

1. Lead Nitrate:

Availability: 15% of the respondents stated that lead nitrate is always available, 25% reported it as rarely available, and 60% mentioned it as not available.

Adequacy: Among those who responded, 40% considered the availability of lead nitrate as adequate, while 60% found it inadequate.

2. Aluminum Sulphate:

Availability: The availability data for aluminum sulphate is missing in the table.

3. Sodium Chloride:

Availability: 35% of the respondents stated that sodium chloride is always available, 55% reported it as rarely available, and 35% mentioned it as not available.

Adequacy: Among those who responded, 30% considered the availability of sodium chloride as adequate, while 70% found it inadequate.

4. Aluminum Nitrate, Zinc Sulphate, Zinc Carbonate, Barium Chloride, Magnesium Carbonate, Magnesium Sulphate, Ammonium Carbonate, Ammonium Sulphate, Ammonium Chloride, Copper Sulphate:

Salts that are always available and adequate for use include sodium chloride (55%), and copper sulphate. The information above suggests that most salts are not available in the chemistry laboratory. The most frequently used salts are those that are often used

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and are present in practically every chemical laboratory. This implies that, if an item is inadequate, then experimental activities that use such salt will not be frequently carried out.

A reagent is a compound or combination of compounds used to treat materials, samples, other compounds, or reactants in a laboratory. A solution is a homogenous mixture that can be liquid, gaseous, or solid and is created by dissolving one or more substances. The availability and adequacy of reagents and solutions in the chemistry laboratories was also looked at.

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Table 7: Availability and Adequacy of reagents and solutions.

Reagents and solutions	Responses (%) AA	RA	NA	Total	Adequacy A	NAd	Total
Potassium Dichromate	15(15%)	35(35%)	50(50%)	100(100%)	15(15%)	85(85%)	100(100%)
Sodium Carbonate	40(40%)	30(30%)	30(30%)	100(100%)	55(55%)	45(45%)	100(100%)
Silver Nitrate	30(30%)	45(45%)	25(25%)	100(100%)	20(20%)	80(80%)	100(100%)
Ammonium Hydroxide	30(30%)	25(25%)	45(45%)	100(100%)	35(35%)	65(65%)	100(100%)
Ammonium Oxalate	20(20%)	40(40%)	40(40%)	100(100%)	30(30%)	70(70%)	100(100%)
Potassium Iodide	25(25%)	25(25%	50(50%)	100(100%)	20(20%)	80(80%)	100(100%)
Potassium Ferrocyanide	25(25%)	40(40%)	35(35%)	100(100%)	25(25%)	75(75%)	100(100%)
Potassium Chromate	20(20%)	35(35%)	45(45%)	100(100%)	35(35%)	65(65%)	100(100%)
Aluminon Reagent	25(25%)	30(30%)	45(45%)	100(100%)	15(15%)	85(85%)	100(100%)
Nessler Reagent	10(10%)	30(30%)	60(60%)	100(100%)	10(10%)	90(90%)	100(100%)
Magneson Reagent	15(15%)	35(35%)	50(50%)	100(100%)	50(50%)	50(50%)	100(100%)
Potassium Permanganate	20(20%)	55(55%)	25(25%)	100(100%)	45(45%)	55(55%)	100(100%)
Ferrous Ammonium Sulphate	15(15%)	30(30%)	55(55%)	100(100%)	20(20%)	80(80%)	100(100%)
Ferrous Sulphate	10(10%)	30(30%)	60(60%)	100(100%)	20(20%)	80(80%)	100(100%)

AA-Always Available, RA-Rarely Available, NA-Not Available A-Adequate, NAd-Not Adequate.

Source: Field Data (November, 2022)

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From the study, these are the responses of the respondents to availability of the listed reagents and solutions in the chemistry laboratory. For the availability of potassium dichromate**,** 15 respondents representing 15% of the sampled respondents emphasised that it is always available (AA), 35(35%), indicated that it is rarely available (RA) whiles 50(50%) revealed that it is never available (NA), for adequate supply of potassium dichromate, 15(15%) said it is adequate whiles 85(85%) revealed that it is not adequate (NAd).

For sodium carbonate, 40(40%) respondents said it is always available (AA), 30(30%) indicated that it is rarely available (RA), whiles 30(30%) indicated that is it never available (NA),for adequate supply of sodium carbonate, data revealed that 55(55%) respondents said it is adequate whiles, 45(45%) revealed that it is not adequate (NAd), for silver nitrate**,** 30(30%) respondents said it is always available (AA), 45(45%) indicated that silver nitrate is rarely available (RA) whiles 25(25%) stressed on the fact that it is never available (NA).

For adequate supply of silver Nitrate, 20(20%) respondents indicated that it is adequate (A) whiles the majority 80(80%) also indicated that it is not adequate (NAd). Ammonium hydroxide, it was found out that 30(30%) respondents stressed that it is always available (AA), 25(25%) respondents emphasised that it is rarely available (RA), whiles 45(45%) also revealed that it is never available (NA). For adequate supply of ammonium hydroxide, 35(35%) said it is adequate (A), whiles 65(65%) respondents emphasised said it is not available (NAd). The rest of the reagents and solutions as listed in the table have the following as their availability as according to the respondents. Ammonium oxalate; AA 20 (20%), RA 40(40%), NA 40 (40%), adequate supply of ammonium hydroxide, A 30(30%), NAd 70(70%), potassium iodide; AA 25(25%), RA 25(25%), NA 50(50%), adequate supply of reagents and solutions A 20(20%),

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NAd 80(80%), next is potassium ferrocyanide; AA 25(25%), RA 40(40%), NA 35(35%), adequate supply of reagents and solutions A 25(25%), NAd 75(75%), potassium chromate; AA 20(20%), RA 35(35%), NA 45(45%), adequate supply of reagents and solutions A 35(35%), NAd 65(65%) , aluminon reagent; AA 25(25%), RA 30(30%), NA 45(45%), adequate supply of reagent and solutions A 15(15%), NAd 85(85%), Nessler reagent; AA 10(5%), RA 30(30%), NA 60(60%), adequate supply of reagents and solutions A 10(10%), NAd 90(90%), magneson reagent; AA 15(15%), RA 35(35%), NA 50(50%), adequate supply of Reagents and Solutions A 50(50%), NAd 50(50%) , potassium permanganate; AA 20(20%), RA 55(55%), NA 25(25%), adequate supply of reagents and solutions A.

Inference from the above data depicts that most of the reagents and solutions are occasionally available while some are not available at all. With respect to their adequacy, the study found out that most of them are not adequate in the chemistry laboratory.

The unavailability and inadequacy of science laboratory resources in the schools makes it difficult for teachers and students to cover areas that require practical activities which leads to non-attainment of the curriculum objectives. Chemistry laboratory equipment is crucial in the teaching of science chemistry without which the subjects lose their value, a preventive implication from pursuing Chemistry and allied courses in higher institutions. It is therefore very crucial to teach basic science practically to promote critical thinking, objectivity and rationality which science entails. The laboratory practical is one of the most effective experiences geared towards the development of scientific skills in students (Tekalign, 2016).

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Section C

4.3 Level of Utilisation of available Chemistry Laboratory Facilities

Research question 2

What is the level of Utilisation of available Chemistry laboratory facilities in the Senior High Schools in the Akuapem South Municipality**?**

This question sought to find out the extent to which chemistry laboratory apparatus and equipment are used by teachers in teaching and learning of chemistry in the schools.

Table 10 displays statistics on the level utilisation of apparatus and equipment's for the teaching and learning of Chemistry**.**

From the table 10, the following are the responses of the respondents to utilisation of chemistry laboratory facilities particularly apparatus and equipment. For the utilisation of burette**;** it was revealed that 45(45%) respondents indicated that the apparatus is always utilised, 35(35%) respondents said it is rarely utilised (RU) whiles 20(20%) stressed on the fact that the apparatus is never utilised (NU), for Pipette, 45(45%) respondents emphasised that it is always utilised (AU), 35(35%) stressed that the apparatus is rarely utilised (RU), whiles 20(20%) indicated that is it never utilised (NU), for Conical Flask; data has it that 40(40%) respondents indicated that it is always utilised (AU), 40(405%) said it is rarely utilised (RU), whiles 20(20%) emphasised that it is never utilised (NU). The rest of the apparatuses and equipment listed in the table have the following as their rate of utilisation as according to the respondents. For funnel; AU 45(45%), RU 25(25%), NU 30(30%), reagent bottles; AU 30(30%), RU 50(50%), NU 20(20%), retort stand and clamp; AU 45(30%), RU 30(30%), NU 25(25%), porcelain tile; AU 15(15%), RU 50(50%), NU 35(35%),

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Table 8: Utilisation of Apparatus and Equipment's in the Chemistry Laboratory

Apparatus and Equipment	Responses (%)			
	AU	RU	NU	Total
Burette	45(45%)	35(35%)	20(20%)	100(100%)
Pipette	45(45%)	35(35%)	20(20%)	100(100%)
Conical Flask	40(40%)	40(40%)	20(20%)	100(100%)
Funnel	45(45%)	25(25%)	30(30%)	100(100%)
Reagent Bottles	30(30%)	50(50%)	20(20%)	100(100%)
Retort Stand and Clamp	45(45%)	30(30%)	25(25%)	100(100%)
Porcelain Tile	15(15%)	50(50%)	35(15%)	100(100%)
Wash Bottle	20(20%)	45(45%)	35(35%)	100(100%)
Measuring Cylinder	30(30%)	50(50%)	20(20%)	100(100%)
Volumetric Flask	30(30%)	45(45%)	25(25%)	100(100%)
Weighing Balance/Electronic Balance	45(45%)	35(35%)	20(20%)	100(100%)
Beaker	40(40%)	35(35%)	25(25%)	100(100%)
Bunsen Burner	45(45%)	30(30%)	25(25%)	100(100%)
Tripod stand	40(40%)	25(25%)	35(35%)	100(100%)
Wire Gauze	40(40%)	35(35%)	25(25%)	100(100%)
Dropper	15(15%)	45(45%)	40(40%)	100(100%)
Test Tube	45(45%)	20(20%)	35(35%)	100(100%)
Test Tube Stand/Rack	25(25%)	35(35%)	40(40%)	100(100%)
Test Tube Brush	5(5%)	35(35%)	60(60%)	100(100%)
Test Tube Holder	20(20%)	45(45%)	35(35%)	100(100%)
Boiling Test Tube	15(15%)	40(40%)	45(45%)	100(100%)
Spatula	10(10%)	65(65%)	25(25%)	100(100%)

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Watch Glass	10(10%)	35(35%)	55(55%)	100(100%)
China Dish	10(10%)	45(45%)	45(45%)	100(100%)
Fire Extinguishers	15(15%)	40(40%)	45(45%)	100(100%)
Gas Supply	10(10%)	40(40%)	50(50%)	100(100%)
Water Supply	70(70%)	15(15%)	15(15%)	100(100%)
Preparatory Table	30(30%)	50(50%)	20(20%)	100(100%)
Preparatory Room	45(45%)	35(35%)	20(20%)	100(100%)
Filter Paper	35(35%)	30(30%)	35(35%)	100(100%)
First Aid Kit	45(45%)	40(40%)	15(15%)	100(100%)

AU-Always Utilised, RU-Rarely Utilised, NU-Never Utilised

Source: Field Data (November, 2022)

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Wash Bottle; AU 20(20%), RU 45(45%), NU 35(35%), measuring cylinder; AU 30(30%), RU 50(50%), NU 20(20%), volumetric flask; AU 30(30%), RU 45(45%), NU 25(25%), weighing balance/electronic balance; AU 45(45%), RU 35(35%), NU 20(20%), beaker; AU 40(40%), RU 45(45%), NU 15(15%), Bunsen burner; AU 45(45%), RU 30(30%), NU 25(25%), tripod stand; AU 40(40%), RU 25(25%), NU 35(35%), wire gauze; AU 40(40%), RU 35(35%), NU 25(25%), dropper; AU 15(15%), RU 45(45%), NU 40(40%), test tube; AU 45(45%), RU 20(20%), NU 35(35%), test tube stand/rack; AU 25(25%), RU 35(35%), NU 40(40%), test tube brush; AU 5(5%), RU 35(35%), NU 60(60%), test tube holder; AU 20(20%), RU 45(45%), NU 35(35%), boiling test tube; AU 15(15%), RU 40(40%), NU 45(45%).

Spatula; AU 10(10%), RU 65(65%), NU 25(25%), watch glass; AU 10(10%), RU 35(35%), NU 55(55%) , China dish; AU 10(10%), RU 45(45%), NU 45(45%), fire extinguishers; AU 15(15%), RU 40(40%), NU 45(45%), gas supply; AU 10(10**%),** RU 40(40%), NU 50(50%), Water Supply; AU 70(70%), RU 15(15%), NU 15(15%), preparatory table; AU 30(30%), RU 50(50%), NU 20(20%), preparatory room; AU 45(45%), RU 35(35%), NU 20(20%), filter paper; AU 35(35%), RU 30(30%), NU 35(35%), and lastly, first aid kit; AU 45(45%), RU 40(40%), NU 15(15%).

From the above apparatuses and equipment's that are occasionally utilised are burette (45%), pipette (45%), conical flask (40%), funnel (45%), retort stan and clamp (45%), beaker (40%), Bunsen burner (45%), and water supply (70%). Those that are not utilised are porcelain title (15%), wash bottle (20%), dropper (15%), test tube stand (25%), test tube brush (5%), test tube holder (20%), boiling test tube (15%), watch glass (10%), China dish (10%), fire extinguisher (15%), gas supply (10%) and preparatory room (30%).

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A careful observation of the above data depicts that a good number of the apparatuses and equipment's are only used occasionally whiles others are not used at all. That is as and when they are required during end of term examinations or in WASSCE.

The above findings can be related to the study conducted by (Neji *et al.*, 2015). In their study, they concluded that laboratory facilities allowed students to interact and understand chemistry concepts and therefore, adequate laboratory equipment's should be provided to enhance teaching and academic performance of students offering chemistry in our schools.

Table 8 shows data on the Utilisation of reagents and solutions for teaching and learning of Chemistry. Table 8 sought to find out how reagents if available are utilised.

From the study, the below are the responses of the participants to the utilisation of the listed reagents and solution in the chemistry laboratory. For the availability of potassium dichromate, it was made evident that 30(30%) respondents said the substance is always utilised (AU), majority of respondents 50(50%) indicated that the substance is rarely used (RU), whiles 10(10%) respondents stressed that it is never utilised (NU). For sodium carbonate, data brought to light that 65(65%) of respondents admitted that the substance is always utilised (AU), 5(5%) indicated that the substance is rarely utilised (RU) whiles 30(30%) respondents stressed that it is never utilised (NU).

For the rest of the reagents and solution, the following data was revealed; silver nitrate; AU 40(40%), RU 35(35%), NU 25(25%), ammonium hydroxide; AU 25(25%), RU 35(35%), NU 40(40%), ammonium oxalate; AU 15(15%), RU 55(55%), NU 30(30%), potassium iodide; AU 10(10%), RU 65(65%), NU 25(25%), potassium ferrocyanide; AU 15(15%), RU 60(60%), NU 25(25%).

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Table 9: Utilisation of Reagents and Solutions in the Chemistry Laboratory

Reagents and Solutions	Responses (%)			
	AU	RU	NU	Total
Potassium Dichromate	30(30%)	50(50%)	10(10%)	100(100%)
Sodium Carbonate	65(65%)	5(5%)	30(30%)	100(100%)
Silver Nitrate	40(40%)	35(35%)	25(25%)	100(100%)
Ammonium Hydroxide	25(25%)	35(35%)	40(40%)	100(100%)
Ammonium Oxalate	15(15%)	55(55%)	30(30%)	100(100%)
Potassium Iodide	10(10%)	65(65%)	25(25%)	100(100%)
Potassium Ferrocyanide	15(15%)	60(60%)	25(25%)	100(100%)
Potassium Chromate	10(10%)	55(55%)	35(35%)	100(100%)
Aluminon Reagent	5(5%)	65(65%)	30(30%)	100(100%)
Nessler Reagent	5(5%)	60(60%)	35(35%)	100(100%)
Magneson Reagent	45(45%)	35(35%)	20(20%)	100(100%)
Potassium Permanganate	45(45%)	35(35%)	20(20%)	100(100%)
Ferrous Ammonium Sulphate	5(5%)	55(55%)	40(40%)	100(100%)
Ferrous Sulphate	40(40%)	45(45%)	15(15%)	100(100%)

AU-Always Utilised, RU-Rarely Utilised, NU-Never Utilised

Source: Field Data (November, 2022)

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Potassium chromate ; AU 10(10%), RU 55(55%), NU 35(35%), aluminon reagent; AU 5(5%), RU 65(65%), NU 30(30%), Nessler reagent; AU 5(5%), RU 60(60%), NU 35(35%), Magneson reagent; AU 45(45%), RU 35(35%), NU 20(20%), potassium permanganate; AU 45(45%), RU 35(35%), NU 20(20%), ferrous ammonium sulphate; AU 5(5%), RU 55(55%), NU 40(40%), ferrous sulphate; AU 40(40%), RU 45(45%), NU 15(15%).

From the above, the most utilised reagents and solutions are sodium carbonate (65%), silver nitrate (40%), Magneson reagent (45%), potassium permanganate (45%) and ferrous sulphate. The reason being that they are commonly known, used and easy to come by. Those that are occasionally utilised are Potassium dichromate (30%), ammonium hydroxide (25%), ammonium oxalate (15%), potassium iodide (10%), potassium chromate (10%) and Nessler reagent (5%).

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Acids are very important in the chemistry laboratory. They are used together with bases in the preparation of salts. Table 9 presents data on utilisation of acids in experiments for teaching and learning of Chemistry.

Table 10: Utilisation of Acids in the Chemistry Laboratory

Acids	**Responses (%)**			
	AU	**RU**	**NU**	**Total**
Hydrochloric Acid	55(55%)	25(25%)	20(20%)	100(100%)
Sulphuric Acid	30(30%)	50(50%)	20(20%)	100(100%)
Nitric Acid	40(40%)	45(45%)	15(15%)	100(100%)
Acetic Acid	10(10%)	50(50%)	40(40%)	100(100%)
Oxalic Acid	10(10%)	60(60%)	30(30%)	100(100%)
Carbonic Acid	10(10%)	65(65%)	25(25%)	100(100%)

AU-Always Utilised, RU-Rarely Utilised, NU-Never Utilised

Source: Field Data (November, 2022)

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From the study, these are the responses of the respondents to the utilisation of acids. For the utilisation of hydrochloric acid, data has it that 55 respondents representing 55% of the total number of respondents indicated that the substance is always utilised (AU). However, few of the respondents 25(25%) said it is rarely utilised (RU), whiles 20(20%) respondents stressed that is it never utilised (NU). For sulphuric Acid, data revealed that 30(30%) respondents stressed that it is always utilised (AU), 50(50%) indicated that it is rarely utilised (RU), whiles 20(20%) said it has never been used (NU). With nitric acid, data revealed the following: AU 40(40%), RU 45(45%), NU 15(15%), Acetic Acid; AU 10(10%), RU 50(50%), NU 40(40%), oxalic acid; AU 10(10%), RU 60(60%), NU 30(30%), and lastly, Carbonic Acid; AU 10(10%), RU 65(65%), NU 25(25%).

From the data hydrochloric acid is most utilised because it is readily available in the chemistry laboratory. This is followed by nitric acid (40%) and then sulphuric acid (30%).

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Bases are chemical agents that are needed in the laboratory for several practical work. Table 10 presents data on the utilisation of bases in experiments for teaching and learning of Chemistry.

Table 11: Utilisation of Bases in the Chemistry Laboratory

Bases	**Responses (%)**			
	AU	**RU**	**NU**	**Total**
Sodium hydroxide	60(60%)	25(25%)	15(15%)	100(100%)
Potassium Hydroxide	30(30%)	45(45%)	25(25%)	100(100%)
Ammonia (liquor)	40(40%)	45(45%)	15(15%)	100(100%)
Calcium Hydroxide	15(15%)	40(40%)	45(45%)	100(100%)
Magnesium Hydroxide	10(10%)	50(50%)	40(40%)	100(100%)
Lithium Hydroxide	10(10%)	55(55%)	35(35%)	100(100%)

AU-Always Utilised, RU-Rarely Utilised, NU-Never Utilised

Source: Field Data (November, 2022)

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From the table, the following were the responses of the respondents to the utilisation of the listed bases. For the utilisation of sodium hydroxide; data has it that 60 respondents representing 60% of the total number of respondents stressed that it was always utilised (AU), 25(25%) said that the substance is rarely utilised (RU) whiles 15(15%) said the substance is ever utilised (NU), with regards to potassium hydroxide; it was revealed that 30(30%) respondents admitted that it is always used (AU), 45(45%) indicated that is it rarely utilised (RU) whiles 25(25%) said the substance is never utilised (NU), for ammonia (liquor); AU 40(40%), RU 45(45%), NU 15(15%), calcium hydroxide; AU 15(15%), RU 40(40%), NU 45(45%), magnesium hydroxide; AU 10(10%), RU 50(50%), NU 40(40%), and lastly, lithium hydroxide; AU 10(10%), RU 55(55%), NU 35(35%).

From the table, the most utilised base is sodium hydroxide and ammonium hydroxide (ammonia liquor).

Chemical salts are very useful in our industries. Some of the uses are; for tanning mineral and leather, dyeing cloths, for bleaching (salts of hydrochloric acids and hypochlorous acid), production of soaps, production of pottery and as a source of chlorine. Many chemical salts are needed in laboratory for students and teachers use.

Table 10 displays data on the utilisation of salts in experiments for teaching and learning of Chemistry.

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Table 12: Utilisation of Salts in the Chemistry Laboratory

Salts	Responses (%)			
	AU	RU	NU	Total
Sodium Chloride	45(45%)	40(40%)	15(15%)	100(100%)
Lead Nitrate	10(10%)	60(60%)	30(30%)	100(100%)
Aluminum Sulphate	15(15%)	55(55%)	30(30%)	100(100%)
Copper Sulphate	15(15%)	45(45%)	40(40%)	100(100%)
Aluminium Nitrate	5(5%)	60(60%)	35(35%)	100(100%)
Zinc Sulphide	10(10%)	50(50%)	40(40%)	100(100%)
Zinc Sulphate	10(10%)	60(60%)	30(30%)	100(100%)
Calcium Carbonate	45(45%)	40(40%)	15(15%)	100(100%)
Barium Chloride	10(10%)	35(35%)	55(55%)	100(100%)
Magnesium Carbonate	5(5%)	35(35%)	60(60%)	100(100%)
Magnesium Sulphate	10(10%)	35(35%)	55(55%)	100(100%)
Ammonium Carbonate	30(30%)	60(60%)	10(10%)	100(100%)
Ammonium Sulphate	10(10%)	40(40%)	50(50%)	100(100%)
Ammonium Chloride	10(10%)	55(55%)	35(35%)	100(100%)

AU-Always Utilised, RU-Rarely Utilised, NU-Never Utilised

Source: Field Data (November, 2022)

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From the Table 12, it was evident that on the utilisation of sodium chloride, it was seen that 45(45%) of the respondent said that it is always utilised (AU), 40(40%) respondents said it is rarely utilised, while 15(15%) said it is never used. With lead nitrate, it was seen that 10(10%), of the respondents said that it is always utilised (AU), 60 respondents representing 60% of the total number of sampled respondents stressed that lead nitrate is rarely utilised (RU) whiles 30 respondents representing 30% admitted that it is Never Utilised (NU), on the utilisation of aluminum sulphate; it was seen that 15(15%) respondents admitted that it is always utilised (AU) 55(55%) respondents stressed that aluminum sulphate is rarely utilised (RU), whiles 30(30%) respondents also admitted that substance was never utilised (NU), on Copper sulphate; AU 15(15%), RU (45(45%) NU 40(40%), Aluminium Nitrate; AU 5(5%), RU 60(60%), NU 35(35%), Zinc Sulphide; AU 10(10%), RU 50(50%), NU 40(40%).

Zinc Sulphate; AU 10(10%), RU 60(60%), NU 30(30%), Calcium Carbonate; AU 45(45%), RU 40(40%), NU 15(15%), barium chloride; AU 10(10%), RU 35(35%), NU 55(55%), magnesium carbonate; AU 5(5%), RU 35(35%), NU 60(60%), Magnesium Sulphate; AU 10(10%), RU 35(35%), NU 55(55%), ammonium carbonate; AU 30(30%), RU 60(60%). NU 10(10%), Ammonium Sulphate; AU 10(10%), RU 40(40%), NU 50(50%), and lastly, ammonium chloride; AU 10(10%), RU 55(55%), NU 35(35%). From the data, it can be inferred that sodium chloride (45%) and calcium carbonate are the most commonly utilised salts while the majority of the salts are not utilised in the chemistry laboratory.

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A species that is amphoteric must have the ability to donate or accept a proton. Amphoteric substances help maintain balance in aqueous solutions of acids and bases.

Table 13 data deals with the utilisation of amphoteric substances in experiments for teaching and learning of Chemistry

Table 13: Utilisation of Amphoteric substances in the Chemistry Laboratory

	Responses (%)			
Amphoteric Substances	**AU**	**RU**	**NU**	**Total**
Aluminum Hydroxide	45(45%)	35(35%)	20(20%)	100(100%)
Beryllium Oxide	10(10%)	65(65%)	25(25%)	100(100%)
Zinc oxide	5(5%)	70(70%)	25(25%)	100(100%)
Lead (II) hydroxide	10(10%)	50(50%)	40(40%)	100(100%)
Dihydrogen monoxide	10(10%)	75(75%)	15(15%)	100(100%)
Ammonium Chloride	10(10%)	55(55%)	35(35%)	100(100%)
Water	30(30%)	60(60%)	10(10%)	100(100%)

AU-Always Utilised, RU-Rarely Utilised, NU-Never Utilised

Source: Field Data (November, 2022)

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From the table, the following were the responses of the respondents to utilisation of amphoteric substances. For the utilisation of aluminum hydroxide; it was seen that 45(45%), of the respondents said that it was always utilised (AU), 35 respondents representing 35% of the total number of sampled respondents stressed that aluminum hydroxide was rarely Utilised (RU) whiles 20 respondents representing 20% admitted that it was never utilised (NU), on the utilisation of beryllium oxide; the total number of respondents who chose AU was 10(10%) which is an indication that 10 of the sampled respondents stressed on the fact that beryllium oxide was always utilised, RU 65(65%), NU 25(25%), zinc oxide; AU 5(5%), RU 70(70%), NU 25(25%), Lead (II) hydroxide; AU 10(10%), RU 50(50%), NU 40(40%), dihydroxide monoxide; AU 10(10%), RU 75(75%), NU 15(15%), ammonium chloride; AU 10(10%), RU 55(55%), NU 35(35%) and lastly water; AU 30(30%), RU 60(60%), NU 10(10%).

Inference from the data depicts that a significant number of respondents rarely utilised or never utilised most of the listed amphoteric substances. The above findings therefore oppose the constructivism theory of learning as proposed by Jerome Bruner.

Jerome Bruner's constructivism theory argues that learning is an active process in which learners construct new ideas or concepts based upon their current or past knowledge, (Bruner, 1996). He also argues that humans generate knowledge and meaning from interaction between their experiences and their ideas. The theory is associated with pedagogic approaches that promote active learning and discovery processes. Hands on experiences are therefore necessary for effective learning as the learner is required to do something in the process of learning. The teacher should try and encourage students to discover principles by themselves. Chemistry teachers can achieve this by giving practicals in the laboratory. The various laboratory experiences expose the learners to hands on activities thus actively participating in the learning

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process. If well planned in a properly set laboratory, laboratory experiences can develop scientific thinking and also develop practical abilities.

Malach (2020) conducted a study on the availability and utilisation of school resources and their impact on students' academic achievement in public day secondary schools in Kisii County, Kenya. The research findings revealed that test tubes, beakers, and flasks were the most readily available and highly utilised chemistry laboratory equipment, as indicated by their high ratings of 4.21 (SD=0.61), 4.21 (SD=0.59), and 4.14 (SD=0.67) respectively on a scale of 1 to 5. Conversely, weighing balances, portable Bunsen burners, and evaporation dishes were among the least available and underutilized equipment in most secondary schools in Kisii County.

Dahar and Faize (2011) argued that while the availability of teaching and learning resources, such as laboratory equipment, is crucial for improving students' academic achievement, proper utilisation of these resources is equally important. Konyango (2011) conducted a study to investigate the effective utilisation of available resources and found that although the laboratories and apparatus were adequate, the results of practical lessons were not impressive. This could be attributed to a lack of functional apparatus, which led to more demonstrations and limited opportunities for students to handle equipment during group work. Consequently, many students faced challenges in effectively using the apparatus during examinations. Konyango's findings support the present study's observation that most public day secondary schools in Kisii County possess the necessary basic laboratory apparatus for teaching science subjects.

Akçayir *et al*., (2016) emphasised that effective utilisation of science laboratory equipment in the teaching and learning process improves students' skills and abilities. They also highlighted the significant role of science laboratory equipment as a key predictor of students' academic achievement. These findings align with Konyango's

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(2011) study, which examined the impact of resource utilisation on chemistry performance in KCSE (Kenya Certificate of Secondary Education) in public secondary schools in Ugunja/Ugenya districts. Konyango's research revealed that although laboratories were available in over 90% of the schools, there was still poor performance in chemistry. The study identified possible attitude problems among teachers and students, low enrollment rates for the subject, and a lack of maintenance leading to non-operational apparatus. Consequently, demonstrations and group experiments were more common than hands-on student activities.

Neji *et al*., (2015) conducted a survey on the utilisation of laboratory facilities and its impact on the academic performance of chemistry students in Calabar, Nigeria. The findings of their analysis revealed that 74% of the laboratory facilities showed non-significant utilisation, while 27% of the facilities were significantly utilised by chemistry students. Specifically, out of the 50 laboratory facilities examined, 37 showed non-significance in terms of utilisation, whereas 1 facility (retort stand, test tube, Conc. HCl, and Conc NaOH) demonstrated significant utilisation. Facilities such as periodic charts, calcium hydroxide, computers, and overhead projectors were found to be non-significant in terms of utilisation, while other facilities showed significance.

However, the study also revealed that there was no significant relationship between the extent of utilisation of laboratory facilities and students' academic performance in Chemistry. This suggests that while certain facilities may be significantly utilised by students, their utilisation alone does not necessarily guarantee improved academic performance.

According to Chandana (2018), who conducted a study on the availability and utilisation of chemistry laboratory facilities in the higher secondary schools of

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Guwahati City, Assam, the research findings revealed a low percentage of schools with available and utilised apparatus and equipment compared to those that remained unutilised. Among the apparatus and equipment studied, beakers, Bunsen burners, condensers, measuring cylinders, spirit lamps, and test tubes were the most utilised in all the schools, with a utilisation rate of 100%.

On the other hand, electrolytic cells were found to be the least utilised, with only 10% of schools incorporating them in their laboratory activities. Interestingly, although condensers were available in all the schools, they were found to be non-functional. Additionally, in 20% of the schools (2 schools), balances and blue litmus were available but not functional.

Furthermore, his study revealed a significant percentage of schools where certain apparatus and equipment were completely unavailable. Copper turning, test tube brushes, thermometers, volumetric flasks, water baths, glass rods, hot plates, microwaves, millimeters, pH meters, and refrigerators were reported as unavailable in 100% of the schools.

In summary, the research conducted by Malach (2020), Konyango (2011), and Akçayir *et al*. (2016) collectively demonstrate the importance of both the availability and effective utilisation of science laboratory equipment in enhancing students' academic achievement. These studies underscore the need for adequate resources, proper maintenance, and opportunities for students to actively engage with the equipment to maximise their learning outcomes.

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Section D

4.4 Skills acquired through laboratory practices

Research Question 3

What laboratory skills are acquired by students in the Akuapem South Municipality?

Teachers were asked to comment on the benefits of laboratory practices in their teaching of chemistry. The information is shown in Table 14.

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Table 14: Benefits of laboratory practices to teachers

Benefits	Responses (%)				
	Strongly Disagree	**Disagree**	**Agree**	**Strongly Agree**	**Total**
Through laboratory practices, I am able to develop scientific applications which aid me in my teachings	10(10%)	10(10%)	35(35%)	45(45%)	100(100%)
I am able to develop positive scientific attitudes	10(10%)	10(10%)	30(30%)	50(50%)	100(100%)
Laboratory practices enable me to understand how science and scientists work	10(10%)	5(5%)	40(40%)	45(45%)	100(100%)
Laboratory practices enhances my ability of formulating scientific questions	-	10(10%)	35(35%)	55(45%)	100(100%)
Laboratory practices enhances my ability of forming hypotheses	10(10%)	5(5%)	40(40%)	45(45%)	100(100%)
I am able to formulate and revise scientific explanations	10(10%)	-	40(40%)	50(50%)	100(100%)
Laboratory practices improves my communication skills and/or my ability to defend scientific arguments	10(10%)	5(5%)	40(40%)	45(45%)	100(100%)
I am able to equip myself with the technical skills in the use of the laboratory equipment	6(6%)	5(5%)	44(44%)	45(45%)	100(100%)

Source: Field Data (2022)

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Table 14 presents data on the benefits of laboratory practicals to the teacher. From the table, it was evident that, through laboratory practices, teachers develop scientific applications which aid them in their teachings. This is so as 10(10%) of the sampled teachers strongly disagreed with the assertion, 10(10%) disagreed, 35(35%) Agreed with the assertion, and 45(45%) strongly agreed with the assertion. Again, it was evident that the chemistry laboratory practical's enables teachers to develop positive scientific attitudes. With this benefit, 10(10%) teachers strongly disagreed with the assertion, 10(10%) disagreed, 30(30%) Agreed with the assertion, and 50(50%) strongly agreed with the assertion. On the benefit of laboratory practices enabling teachers understand how science and scientists work", data has it that 10 teachers representing 10% of the total number of the sampled teachers strongly disagreed with the assertion, 5(5%) disagreed, 40(40%) Agreed with the assertion, and 45(45%) strongly agreed with the assertion. With respect to laboratory practices enhancing teacher's ability of formulating scientific questions, it was realised that no respondent strongly disagreed with the assertion, 10(10%) respondents disagreed, 35(35%) agreed with the assertion, and 55(55%) strongly agreed with the assertion.

Wirth reference to laboratory practices enhancing teacher's ability of forming hypotheses, it was revealed that 10(10%) of the sampled teachers strongly disagreed with the assertion, 5(5%) disagreed, 40(40%) Agreed with the assertion, and 45(45%) strongly agreed with the assertion. Another benefit, "I am able to formulate and revise scientific explanations", 10(10%) of the sampled teachers strongly disagreed with the assertion, no respondent disagreed to the statement, 40(40%) agreed with the assertion, and 50(50%) strongly agreed with the assertion. On laboratory practices improving teacher's communication skills and/or their ability to defend scientific arguments, data has it that 10(10%) of the sampled teachers strongly disagreed with the assertion, 5(5%)

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disagreed, 40(40%) Agreed with the assertion, and 45(45%) strongly agreed with the assertion. Lastly, on the benefit of teachers being able to equip themselves with the technical skills in the use of the laboratory equipment, data brought to light that 6(6%) respondents strongly disagreed with the assertion, 5(5%) disagreed, 44(44%) Agreed with the assertion, and 45(45%) strongly agreed with the assertion. From the data presented, it can be inferred that the majority of the sampled teachers agreed and strongly agreed to the various benefits on the utilisation of the chemistry laboratory resources. According to Twoli (2006), one of the most outstanding benefits of chemistry laboratory practices to the teacher is to improve his manipulative skills also known as motor skills that is the skills to deal with the ability to handle and arrange apparatus and materials for proper experimentation (Twoli, 2006). If teachers have proper manipulative skills, they will make accurate observations and record the data collected accurately. This will then translate to accurate interpretation.

Manipulative skills include handling, arranging, fixing, pouring, heating, filtering and weighing. Ausubel (2018) on the other hand observed that the laboratory gives both the student and the teacher appreciations of the spirits and the method of science, promotes problem solving, analytic and generalisation ability, provide the teacher with some understanding of the nature of science. Woolnough and Allsop (2015) stresses that if we want the students and teachers to acquire skills that are used by practicing scientists and if we are concerned with the teaching of the process skills of science, practical work seems to be vital in this context. Levinson (2014) cautions that practical work activity should not be a sit and watch demonstration or a recipe practical because such do not promote intellectual or cognitive skill development.

Students were asked to comment on the skills they acquire through laboratory practices. The information is shown in Table 15.

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Table 15: Skills acquired by students through laboratory practice.

Skills	Responses (%)				
	Strongly Disagree	**Disagree**	**Agree**	**Strongly Agree**	**Total**
I understand the chemistry concepts better during laboratory practical's	10(10%)	5(5%)	35(35%)	50(50%)	100(100%)
I am able to better develop my chemistry practical skills	10(10%)	10(10%)	30(30%)	50(50%)	100(100%)
The laboratory practical's enriches my problem solving abilities	-	5(5%)	40(40%)	55(55%)	100(100%)
It enables me to have scientific habits of mind. That is enabling me gain knowledge through scientific means.	-	10(10%)	35(35%)	55(45%)	100(100%)
Laboratory practices improves my communication skills and/or my ability to defend scientific arguments	10(10%)	10(10%)	35(35%)	45(45%)	100(100%)
It enables me to develop a high interest in chemistry. That is, motivating me to learn the chemistry with ease.	3(3%)	-	47(47%)	50(50%)	100(100%)
Laboratory practices instills in me the ability to work in a team, that is working together with my colleagues (Skills in teamwork)	10(10%)	5(5%)	40(40%)	45(45%)	100(100%)
It increases my imaginative and creative ability	6(6%)	7(7%)	44(44%)	43(43%)	100(100%)

Source: Field Data (November, 2022)

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From the study, this is the reactions of the respondents to the skills. For the skill of "I understand the chemistry concepts better during laboratory practical's", it was realised that 10(10%) students strongly disagreed with the assertion, 5(5%) students disagreed, 35(35%) Agreed with the assertion, and 50(50%) strongly agreed with the assertion. Again, on the benefit of "I am able to better develop my chemistry practical skills", it was realised that 10(10%) students strongly disagreed with the assertion, 10(10%) disagreed, 30(30%) Agreed with the assertion, and 50(50%) strongly agreed with the assertion. Another skill, "the laboratory practical's enriches my problem solving abilities, no student strongly disagreed with the assertion, 5(5%) disagreed, 40(40%) Agreed with the assertion, and 55(55%) strongly agreed with the assertion, on the skill of chemistry laboratory practical's enabling students to have scientific habits of mind, the data revealed that 0 strongly disagreed with the assertion, 10(10%) disagreed, 35(35%) agreed with the assertion, and 55(55%) strongly agreed with the assertion.

With respect to the skill of Laboratory practices improving students' communication skills and/or their ability to defend scientific arguments, it was brought to light that 10(10%) students strongly disagreed with the assertion, 10(10%) disagreed, 35(35%) Agreed with the assertion, and 45(45%) strongly agreed with the assertion. Another benefit, "It enables me to develop a high interest in chemistry, that is, motivating me to learn the chemistry with ease", it was seen that 3(3%) students strongly disagreed with the assertion, 0disagreed, 47(47%) Agreed with the assertion, and 50(50%) strongly agreed with the assertion. With reference to the skill of Laboratory practices instilling in students the ability to work in a team, that is working together with their colleagues (Skills in teamwork), the data has it that 10(10%) students strongly disagreed with the assertion, 5(5%) disagreed, 40(40%) Agreed with the assertion, and 45(45%) strongly agreed with the assertion. On the last skill that is "It increases my imaginative and

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creative ability”, 6(6%) students strongly disagreed with the assertion, 7(7%) disagreed, 44(44%) agreed with the assertion, and 43(43%) strongly agreed with the assertion. It can be inferred from the above data that a significant number of students recognised and acknowledged the benefits of the chemistry laboratory practicals in their various schools. The science laboratory has a direct effect on both students’ attitudes and academic performance as per the instructional theory of learning interaction.

This finding is consistent with the research conducted by Asefa, Befekadu, and Alemayehu (2023) in their study titled "Assessment of Status and Practices of Chemistry Laboratory Organisation and Utilisation in 'Adet' and 'Debremewii' Secondary Schools, Amhara Region, Ethiopia." The authors emphasised the multifaceted nature of learning, highlighting the interplay between students' motivation, physical facilities, teaching resources, teaching skills, and curriculum demands.

Laboratory practice plays a crucial role in equipping students with a range of valuable skills. Numerous studies have underscored the significance of laboratory experiences in skill development. For instance, Erdogan (2020) highlighted how laboratory practice enhances critical thinking, problem-solving, and data analysis skills among students. Johnstone (2010) also emphasised the acquisition of scientific inquiry skills through hands-on experiments.

Furthermore, Furtak, Seidel, Iverson, and Briggs (2012) and Hofstein and Lunetta (2004) emphasised the role of laboratory practice in promoting scientific literacy and deeper understanding of scientific concepts. Collaborative skills, practical laboratory techniques, and safety protocols are additional skills fostered through laboratory practice, as noted by Banerjee (2018) and Hofstein, Navon, Kipnis, and Mamlok-Naaman (2005).

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Section E

4.5 Challenges chemistry teachers face

Research question 4

What are the challenges chemistry teachers face in using laboratory resources in teaching and learning?

Responses on challenges chemistry Teachers face in using laboratory resources for teaching and learning are shown in Table 18 below.

The analysis of the data in table 18 revealed that the respondents concurred that a variety of factors prevent the teaching of chemistry practical in the Akuapem South Municipality. While 35(35%) strongly agreed that some chemistry teachers are not willing to conduct chemistry practical's, 20(20%) also agreed to that, while 20(20%) and 25(25%) strongly disagreed and disagreed to the assertion respectively. This means 55% agreed that teachers are unwilling to conduct practicals.

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Table 16: Challenges teachers faced in using chemistry laboratory facilities for teaching and learning.

Challenges	Responses (%)			
	Strongly agree	Agree	Disagree	Strongly disagree
Some chemistry teachers' are not willing to conduct practical's.	35(35%)	20(20%)	20(20%)	25(25%)
Teachers' inability to improvise unavailable laboratory apparatus and materials	55(55%)	15(15%)	20(20%)	10(10%)
Majority of students believe that chemistry is a difficult subject with numerous theories and calculations.	40(40%)	25(25%)	20(20%)	15(15%)
Chemistry practical lessons are harder to teach because of students' inconsistent attendance in practical classes.	30(30%)	35(35%)	15(15%)	20(20%)
Lack of supportive personnel/technician to help chemistry teachers during practicals	65(65%)	15(15%)	10(10%)	10(10%)
There is no time allocation for chemistry practical lessons	60(60%)	25(25%)	10(10%)	5(5%)
Large class size of students does not allow for proper/frequent practical lessons	55(55%)	20(20%)	15(15%)	5(5%)
Some chemistry instructors lack professionalism and manipulative skills.	35(25%)	20(20%)	15(15%)	30(30%)

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For Teachers' inability to improvise unavailable laboratory apparatus and equipment, 55(55%) respondents strongly agreed, 15(15%) agreed, 20(20%) respondents strongly disagreed and 10(10%) of the respondent disagreed; 65(65%) strongly agreed with the fact that majority of students believe that chemistry is a complex subject with numerous theories and calculations, while 20(20%) strongly disagreed and 15(15%) disagreed. With regards to chemistry practical lessons being harder to teach because of students' inconsistent attendance in practical classes, 30(30%) of the respondents strongly agreed, 35(35%) agree, 15(15%) strongly disagreed and 20(20%) agreed.

Eighty (80%) of the students strongly agree that lack of supportive personnel/technician to help chemistry teachers during practical's affects the teaching of practical work, while 10(10%) and 10(10%) strongly disagreed and disagreed respectively. With regards to there is no time allocation for chemistry practical lessons, 60(60%) strongly agreed, 25(25%) agreed, 10(10%) strongly disagreed and 5(5%) disagreed. For large class size of students which does not allow for proper/ frequent practical lessons, 55(55%) strongly agreed, 20(20%) agreed, 15(15%) strongly disagreed and 5(5%) agreed, and 35(35%) of the respondents strongly agree that some chemistry instructors lack professionalism and manipulative skills, 20(20%) agree, 15(15%) strongly disagreed and 30(30%) disagreed.

Inference from the above data depicts that majority of chemistry teachers in the Akuapem South Municipality are faced with the problem of unwillingness to conduct chemistry practical's, teachers' inability to improvise practical equipment's/apparatus, the students believe about the complex/abstract nature of chemistry. In addition, a significant number of chemistry teachers in the municipality were also faced with the problem of large classes which does not pave way for frequent practical lessons. Large class sizes can limit individual attention and access to laboratory resources, hindering

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effective supervision and hands-on learning experiences. Research suggests that optimising class size and implementing small-group activities can enhance student engagement and participation (Van Dijk *et al*., 2014). The above findings can be related to a study conducted by Pareek (2019), who argued that the quality of teaching and learning experience depends on the extent of the adequacy of laboratory facilities in secondary schools and the teacher's effectiveness in the use of laboratory facilities with the aim of facilitating and providing meaningful learning experiences in the learners. Investigating the relationship between adequacy and academic performance in chemistry, (Mogaka, & Ogeta, 2017). examined the adequacy of laboratory facilities using frequency counts and percentages.

Chemistry is a practically oriented science subject which presents students with abstract ideas. This is because it deals with invisible concepts such as atoms. The only way to remove the abstractness of the subject is to give students experiences that can enhance their understanding of the subject. Most of these experiences can only be given in the laboratory (Ekesi *et al.*, 2009). Miller (2004) observes that abstract ideas cannot simply be transferred from teacher to students. The students must play an active role in appropriating these ideas and making personal sense of them.

According to Hofstein (2016), laboratory activity (practical work) is contrived learning experiences in which students interact with materials to observe phenomena. These experiences may have different levels of structure specified by teachers or laboratory handbook (manuals) and may include phases of planning and design, analysis, and interpretation as the central performance phase. It is generally believed that constant practice leads to proficiency in what the learner learns during classroom instruction; hence, the dictum "practice makes perfect" (Pareek, 2019).

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CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.0 Overview

This chapter entails the summary, conclusion, and recommendations the researcher has made towards the study. It also puts forward some suggestions for further study.

5.1 Summary

Chemistry instruction is highly dependent on the availability and successful use of instructional resources. The secret to a breakthrough in the growth of science and technology is a practical-based approach to teaching and learning of chemistry. As a result, the study especially examined the extent of utilisation of chemistry laboratory resources in senior high school Akuapem South Municipality. Students' interest in the subject is increased by the practical work they do in class to understand the basic scientific ideas.

A Chemistry laboratory is therefore essential to the teaching of the subject and has a big impact on students' academic success in the subject.

According to the study's findings, senior high schools in the Akuapem South Municipality had laboratories that were not adequately stocked with apparatuses/equipment, reagents and solutions to support teaching and learning of chemistry lessons. The survey showed that burettes, pipette, funnel(plastic/glass), beakers(plastic/glass), conical flasks retort stand/clamps, cotton wool, water, are the most available, easily accessible and used in the laboratory. Chemical balances, Bunsen burners, filter paper, fume chambers, preparatory rooms and evaporation dishes are some of the least common and least-used apparatuses/equipment in the laboratory. Sodium chloride, copper sulphate [copper (II) tetraoxosulphate (VI)], sodium carbonate [sodium trioxocarbonate (IV)], ammonia (liquor) [ammonia hydroxide], potassium

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permanganate [potassium tetraoxomanganate (VII)], hydrochloric acid, nitric acid, aluminum hydroxide and Magneson reagent are the commonly available and utilised chemicals, reagents, and solutions.

5.2 Conclusion

Based on the discussion of the results on the use of the chemistry laboratory in teaching the subject especially the practical aspects, the researcher observed that: Most of the secondary schools surveyed in the Akuapem South Municipal did not have well equipped chemistry laboratories in terms of equipment and apparatuses.

Those schools that have laboratories lacked qualified chemistry teachers and trained laboratory Assistants. For teachers to succeed in their careers, school administrators and the government should construct and outfit chemistry laboratories and staff the laboratory with qualified laboratory technicians who can support instructors and students during practical lessons.

5.3 Recommendations

Based on the findings of this study, the researcher made the following recommendations.

1. To address the issue of limited hands-on experience, it is crucial for educational institutions to prioritise the provision of adequate apparatus and resources in chemistry laboratories. This includes regular maintenance of existing equipment, investment in new apparatus when needed, and ensuring that laboratory infrastructure aligns with the educational goals and curricula.
2. All the topics in chemistry which are practically oriented should be taught in the laboratory, using all the necessary equipment and reagents. By using the chemicals/reagents, the students would acquire the skills involved in handling dangerous substances.

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3. Additionally, educators can explore alternative approaches, such as virtual simulations or collaborative partnerships with external laboratories, to supplement the practical work experience when apparatus availability is limited.
4. The science (chemistry) teachers should be encouraged to attend conferences, seminars, and workshops. This will help them to learn new things, methods and acquire new skills in teaching difficult chemistry concepts.
5. The science teachers should be motivated through payment of special allowance; or they may be placed one step ahead of their counterparts on the same salary grade level.
6. There should be more periods on the timetable for practical chemistry lessons.
7. The teachers and their students should use the correct chemistry textbooks recommended by the Ministry of Education in teaching the students. As a matter of urgency, adequate provision should be made with regards to a practical guide or workbook for students and teachers if any meaningful achievement is expected from them.
8. Since chemistry is an experimental discipline, more focus on the practical application or a balance of theoretical and practical application should be given.
9. To teach chemistry, science teachers must complete the necessary and sufficient training, with a focus on how to execute practical instructions successfully to increase students' interest and success in chemistry classes.

5.4 Suggestions for further studies

The issue concerning the availability and utilisation of chemistry laboratory equipment is very wide due to its multidisciplinary origin thus covering everything in one study is nearly impossible.

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Therefore, future research should consider chemistry teachers' attitude toward chemistry practical work in some Senior high school.

The current study could be replicated in different research areas to determine whether similar findings can be established or not.

Future studies may consider increasing the sample observation and the deployment of a structural equation model or factor analysis to identify more robust relationships between chemistry laboratory usage and academic performance.

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APPENDIX I

UNIVERSITY OF EDUTION WINNEBA

FACULTY OF SCIENCE

DEPARTMENT OF SCIENCE EDUCATION

CONSENT TO PARTICIPATE IN RESEARCH

Dear respondent, you are humbly invited to participate in a research study entitled**; UTILISATION OF CHEMISTRY LABORATORY RESOURCES FOR TEACHING AND LEARNING IN SENIOR HIGH SCHOOLS IN AKUAPEM SOUTH, ABURI**.

The purpose of the study is to explore the availability and utilisation of chemistry laboratory.

Resources for teaching and learning in the Akuapem South Municipality of Ghana.

Your participation in the study will contribute to a better understanding of the above research study. Kindly note that the researcher respects privacy a lot and as a result, all the information given will strictly be used for academic purpose/ research only and will be treated with the utmost confidentiality. Your honesty is therefore very critical and paramount when you respond to the questionnaire.

If you have any questions about the study; contact the researcher, **Adeline Bedjabeng** on 0243811679 or send an email to delineja@gmail.com

Thank you for your consideration. Your help is greatly appreciated.

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APPENDIX II

QUESTIONNAIRE

(Please tick √ in the box besides option/s matching your response or fill in where appropriate)

SECTION A: PERSONAL INFORMATION OF RESPONDENT (TEACHERS AND STUDENTS)

1. Gender: Male [ ] Female [ ]
2. Occupation: Teacher [ ] Student [ ]
3. Age:

   From 15 – 20 years [ ]

   Between 25-29 years [ ]

   Between 30-39 years [ ]

   Between 40-50 years [ ]

   Above 50 years [ ]
4. How long have you taught in GES? (Teachers only)

   1-5 years [ ]

   6-10years [ ]

   11-15 years [ ]

   16-20 years [ ]

   21- 25 years [ ]

   26-30 years [ ]

   Above 30 years [ ]
5. Highest Academic qualification of teachers (Teachers only).

   1st Degree [ ]

   Masters [ ] Msc. [ ] Mphil [ ]

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Ph.D [ ]

Others [ ], please specify…………………………

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SECTION B: AVAILABILITY OF CHEMISTRY LABORATORY FACILITIES FOR TEACHING AND LEARNING.

S. No	APPARATUSA	AA	RA	NA	ADEQUACY	
					A	NAd
1	Burette					
2	Pipette					
3	Conical flask					
4	Glass Funnel					
5	Reagent Bottles					
6	Beakers					
7	Porcelain Tile					
8	Gas jar					
9	Measuring Cylinder					
10	Volumetric Flask					
11	Weighing bottles					
12	Stirring Rod					
13	Thermometers					
14	Dropping pipette					
15.	Graduated cylinders					
16	Indicator bottle					

AA-Always Available, RA-Rarely Available, NA-Not Available A-Adequate, NAd-Not Adequate.

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S. No	EQUIPMENT	AA	RA	NA	ADEQUACY	
					A	NAd
1	Retort Stands/Clamps					
2	First Aid Box					
3	Spatula					
4	Test tube racks					
5	Tripod Stands					
6	Wash bottles					
7	Wire gauze					
8	Water baths					
9	Fume chambers/cupboards					
10	Bunsen burner					
11	Filter paper					
12	Litmus paper					
13	Fire Extinguisher					
14	Cotton wool					
15	Chromatography paper					
16	Spring and chemical balance					
17	Dropping pipette					
18	Gas supply					
19	Preparatory room					
20	Water supply					

AA-Always Available, RA-Rarely Available, NA-Not Available A-Adequate, NAd-Not Adequate

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S. No	**SALTS**	**AA**	**RA**	**NA**	**ADEQUACY**	
					A	**NAd**
1	Lead Nitrate					
2	Aluminium Sulphate					
3	Aluminium Nitrate					
4	Zinc Sulphide					
5	Zinc Sulphate					
6	Calcium Carbonate					
7	Barium Chloride					
8	Magnesium Carbonate					
9	Magnesium Sulphate					
10	Ammonium Carbonate					
11	Ammonium Sulphate					
12	Ammonium Chloride					

AA-Always Available, RA-Rarely Available, NA-Not Available A-Adequate, NAd-Not Adequate.

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S. No	REAGENTS AND SOLUTIONS	AA	RA	NA	ADEQUACY	
					A	NAd
1	Potassium dichromate					
2	Sodium Carbonate					
3	Silver Nitrate					
4	Ammonium hydroxide					
5	Ammonium Oxalate					
6	Potassium Iodide					
7	Potassium ferrocyanide					
8	Potassium Chromate					
9	Aluminon Reagent					
10	Nessler Reagent					
11	Magneson Reagent					
12	Potassium Permanganate					
13	Ferrous Ammonium Sulphate					
14	Ferrous Sulphate					

AA-Always Available, RA-Rarely Available, NA-Not Available A-Adequate, NAd-Not Adequate.

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SECTION C: UTILISATION OF CHEMISTRY LABORATORY FACILITIES FOR TEACHING AND LEARNING

S. No	APPARATUS AND EQUIPMENT	AU	RU	NU
1	Burette			
2	Pipette			
3	Conical flask			
4	Funnel			
5	Reagent Bottles			
6	Retort Stand and Clamp			
7	Porcelain Tile			
8	Wash Bottle			
9	Measuring Cylinder			
10	Volumetric Flask			
11	Weighing Balance/Electronic Balance			
12	Beaker			
13	Bunsen Burner			
14	Tripod stand			
15	Wire Gauze			
16	Dropper			
17	Test Tube			
18	Test Tube Stand/Rack			
19	Test Tube Brush			
20	Test Tube Holder			
21	Boiling Test Tube			
22	Spatula			
23	Watch glass			
24	China Dish			
25	Fire Extinguishers			
26	Gas Supply			
27	Water Supply			
28	Preparatory Table			
29	Preparatory Room			
30	Filter paper			
31	First Aid Kit			

AU-Always Utilised, RU-Rarely Utilised, NU-Never Utilised

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S. No	REAGENTS AND SOLUTIONS	AU	RU	NU
1	Potassium dichromate			
2	Sodium Carbonate			
3	Silver Nitrate			
4	Ammonium hydroxide			
5	Ammonium Oxalate			
6	Potassium Iodide			
7	Potassium ferrocyanide			
8	Potassium Chromate			
9	Aluminon Reagent			
10	Nessler Reagent			
11	Magneson Reagent			
12	Potassium Permanganate			
13	Ferrous Ammonium Sulphate			
14	Ferrous Sulphate			

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S. No	ACIDS	AU	RU	NU
1	Hydrochloric Acid			
2	Sulphuric Acid			
3	Nitric Acid			
4	Acetic Acid			
5	Oxalic Acid			
6	Carbonic acid			

S. No	Bases	AU	RU	NU
1	Sodium Hydroxide			
2	Potassium Hydroxide			
3	Ammonia(liquor)			
4	Calcium Hydroxide			
5	Magnesium Hydroxide			
6	Lithium Hydroxide			

S. No	SALTS	AU	RU	NU
1	Lead Nitrate			
2	Aluminium Sulphate			
3	Aluminium Nitrate			
4	Zinc Sulphide			
5	Zinc Sulphate			
6	Calcium Carbonate			
7	Barium Chloride			
8	Magnesium Carbonate			
9	Magnesium Sulphate			
10	Ammonium Carbonate			
11	Ammonium Sulphate			
12	Ammonium Chloride			

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S. No	AMPHOTERIC SUBSTANCES	AU	RU	NU
1	Aluminium hydroxide			
2	Beryllium oxide			
3	Zinc oxide			
4	Lead(II)hydroxide			
5	Dihydrogen monoxide (Water)			

AU-Always Utilised, RU-Rarely Utilised, NU-Never Utilised.

SECTION D: BENEFITS OF LABORATORY PRACTICES (FOR TEACHERS ONLY)

Please indicate your level of agreement on the following benefits of laboratory practices.

4=Strongly Agree, 3=Agree, 2=Disagree and 1=Strongly Disagree

S. No	Benefits	1	2	3	4
1	Through laboratory practices, I am able to develop scientific applications which aid me in my teachings				
2	I am able to develop positive scientific attitudes				
3	Laboratory practices enable me to understand how science and scientists work				
4	Laboratory practices enhances my ability of formulating scientific questions				
5	Laboratory practices enhances my ability of forming hypotheses				
6	I am able to formulate and revise scientific explanations				
7	Laboratory practices improves my communication skills and/or my ability to defend scientific arguments				
8	I am able to equip myself with the technical skills in the use of the laboratory equipment				

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Any other benefits?, Please specify

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SKILLS OF LABORATORY PRACTICES (FOR STUDENTS ONLY)

Please indicate your level of agreement on the following benefits of laboratory practices.

4=Strongly Agree, 3=Agree, 2=Disagree and 1=Strongly Disagree

S. No	**Skills**	**1**	**2**	**3**	**4**
1	I understand the chemistry concepts better during laboratory practical's				
2	I am able to better develop my chemistry practical skills				
3	The laboratory practical's enriches my problem solving abilities				
4	It enables me to have scientific habits of mind. That is enabling me gain knowledge through scientific means.				
5	Laboratory practices improves my communication skills and/or my ability to defend scientific arguments				
6	It enables me to develop a high interest in chemistry. That is, motivating me to learn the chemistry with ease.				
7	Laboratory practices instills in me the ability to work in a team, that is working together with my colleagues (Skills in teamwork)				
8	It increases my imaginative and creative ability				

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Any other benefits? Please specify

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SECTION E

CHALLENGES CHEMISTRY TEACHERS FACE IN USING LABORATORY RESOURCES FOR TEACHING AND LEARNING.

Please indicate your level of agreement on the challenges teachers face in using laboratory resources in teaching and learning.

4=strongly agree, 3=Agree, 2=Disagree, 1=Strongly disagree

S. No	**Challenges**	1	2	3	4
1	chemistry teachers' are not willing to perform practical's.				
2	Teachers inability to improvise with unavailable laboratory apparatus and equipment.				
3	majority of students believe that chemistry is a complex subject with numerous theories.				
4.	Chemistry practical lessons are harder to teach because of students' inconsistent attendance in practical classes.				
5	Lack of supportive personnel/technician to help chemistry teachers during practical's				
6.	There is no time allocation for chemistry practical lessons				
7.	Large class size of students does not allow for proper practical lessons				

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APPENDIX III

INTRODUCTORY LETTER

UNIVERSITY OF EDUCATION, WINNEBA
FACULTY OF SCIENCE EDUCATION
DEPARTMENT OF INTERGRATED SCIENCE EDUCATION
P. O. Box 25, Winneba, Ghana
ise@uew.edu.gh
+233 (020) 2041077

Our ref. No.: ISED/PG.1/Vol.1/17
Your ref. No.:

Date: 18th May, 2022

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

LETTER OF INTRODUCTION
MS ADELINE BEDJABENG

We write to introduce, MS BEDJABENG a postgraduate student of the Department of Integrated Science Education, University of Education, Winneba, who is conducting a research titled:

Extent of utilization of chemistry laboratory resource for teaching and learning of Chemistry in second cycles institution in Akuapem-South Municipality.

We would be very grateful if you could give her the assistance required.

Thank you.

Yours faithfully,

ALEXANDRA N. DOWUONA
CHIEF ADMIN. ASSISTANT
For : HEAD OF DEPARTMENT