UNIVERSTY OF EDUCATION, WINNEBA

# FACTORS INFLUENCING PERFORMANCE IN CHEMISTRY PRACTICAL WORK: A CASE STUDY IN SELECTED SCHOOLS IN GREATER ACCRA, CENTRAL, EASTERN AND VOLTA REGIONS

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2017

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A DISSERTATION SUBMITTED TO THE DEPARTMENT OF SCIENCE, FACULTY OF SCIENCE EDUCATION, SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES OF UNIVERSTY OF EDUCATION – WINNEBA IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF EDUCATION IN SCIENCE (CHEMISTRY)

JUNE, 2017

# DECLARATION

This project is the result of research work undertaken by Raphael Foster Ayittey in the Department of Chemistry, University of Education -Winneba and has neither in part nor in whole been presented for another degree elsewhere.

Sign: …………………………… Date: ……………………………

Raphael Foster Ayittey

Sign: …………………………… Date: ……………………………

Mr. Lord Hunnour Bobobee

(Supervisor)

# DEDICATION

This book is dedicated to my family.

# ACKNOWLEDGEMENT

To Yahweh be all the glory and praise, for His tender mercies, loving kindness and grace to carry out this research and to finish it well.

I would like to express my greatest gratitude to Mr. Lord Hunnour Bobobee for his valuable support, advice, enthusiasm and encouragement during the period of the study. Also his patience, commitment, insight and encouraging words inspired me and kept me going even when the going was tough. Special thanks go to the teachers and students who completed the questionnaires.

I also wishes to acknowledge my family and church members for their support and prayers, especially the restorer of the divine temple ordinance and the leader of Seventh Day Congregation of Theocracy – Apostle Kadmiel E.H Agbalenyoh.

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## ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| **APU** | Assessment of Performance Unit |
| **BOG** | Board of Governors |
| **CAT** | Continuous Assessment Test |
| **CSQ** | Chemistry Students' Questionnaire |
| **CTQ** | Chemistry Teachers' Questionnaire |
| **DAG** | Document Analysis Guide |
| **WASSCE** | West Africa Senior School Certificate Examination |
| **WAEC** | West Africa Examination Council |
| **LOS** | Lesson Observation Schedule |
| **MoE** | Ministry of Education |
| **PTA** | Parents Teachers Association |
| **SPSS** | Statistical Package for Social Sciences |

## ABSTRACT

This study concerned itself with practical work conducted in chemistry in senior high schools. It examined whether the way practical experiences were presented to the students and students' engagement in it enhanced the attainment of goals of practical work. The study also examined the teachers' and students' attitudes towards practical work in chemistry. The study was conducted in four selected schools in four regions of Ghana, using a descriptive survey design.. It involved four (4) chemistry teachers and 100 Form Three chemistry students comprising 60 boys and 40 girls. The study utilised questionnaires, lesson observation schedules and document analysis guide to collect data. The main findings of the study indicated that science laboratories in senior high schools in the selected regions were fairly equipped with basic apparatus, chemicals and materials and students were indeed involved in a variety of practical activities in chemistry.

# CHAPTER ONE

## INTRODUCTION

### 1. 0 Overview

Ghana like other developing countries invests heavily in the teaching and learning of practical work in science and chemistry in particular. However, this high input of resources do not seem to translate into the performance of students in practical work as always reported in the chief examiner's reports. This chapter introduces the study on factors influencing performance in chemistry practical work by giving the background to the study and the statement of the problem. Also, included in this chapter are: objectives of the study, research questions, significance of the study, scope and limitations of the study, basic assumptions and conceptual framework of the study. The chapter concludes by giving operational definitions of some of the terms that are used in the study.

### 1.2 Background to the Study

The government of Ghana recognizes the importance of science and mathematics in the realisation of its vision 2020 agenda; to become a globally competitive and prosperous country by 2020. In the vision 2020 agenda document, each Ghanaian citizen is expected to be scientifically and technologically literate by the year 2020. It is hoped that, the nation would attain the status of a middle-income country by 2020. This reflected in the amount of resources both human and otherwise that are channelled towards enhancing the teaching and learning of science and mathematics at all levels of the educational system. At the senior high school level, a number of intervention strategies have been put in place such as practical works and demonstration activities to ensure that, the teaching/learning of these subjects is as effective as possible.

For centuries, chemistry educators believe that practical chemistry is indispensable in teaching and learning of the subject. Specifically, the importance of chemistry practical is as follows:

1. It helps students develop science process skills such as observing, classifying, predicting, measuring, drawing, recording data, hypothesizing, etc.

2. It promotes the development of scientific attitudes such as objectivity, honesty, curiosity, patience, open-mindedness, etc.

3. It helps students to understand and appreciate the spirit and methods of science such as problem solving, analytic minds and methods of science. Baird (1996).

4. It is used to reinforce what is learnt in the theory class and hence encourages the spirit of experimentation.

5. It arouses and maintains interest and curiosity in chemistry.

6. It helps students to develop manipulative skills and proficiency in writing reports.

7. It enhances students' better understanding of concepts and principles and by so doing, significantly contributes to students' achievements in chemistry.

8. It encourages students to be active in the class, in other hand, discourages abstraction, rote memorization and inattentiveness in class. Baird (1990)

9. It leads to fundamental and applied research in chemistry at all levels of education.

10. It helps to verify laws and theories that the students have already learnt.

Practical examination in chemistry, tests whether candidates have acquired certain skills and competencies which include:

1. manipulative skills for example, correct measurement of volume using a variety of measuring instruments
2. ability to make accurate observations; those that lead to useful deductions
3. ability to record observations accurately
4. ability to make accurate deductions
5. ability to follow a set of instructions and carry out experiments. The skills and competencies assessed by WAEC in practical examination are in line with some of the general objectives of teaching/learning chemistry as prescribed in the chemistry syllabus. Examples of such objectives are:

i) to select and handle appropriate apparatus for use in experimental work

ii) to make accurate measurements, observations and draw logical conclusions from experiments

The chemistry practical examination is usually marked out of 40 marks but the performance has been below average as attested to the statistics in table 1.

*Table 1: Performance of students in WASSCE Chemistry Practical Examination in four Selected Schools*

| Year | Candidature | Maximum score | Mean score | Standard deviation |
|---|---|---|---|---|
| 2011 | 510 | 40 | 13.04 | 4.64 |
| 2012 | 560 | 40 | 12.22 | 6.22 |
| 2013 | 575 | 40 | 14.54 | 7.01 |
| 2014 | 600 | 40 | 14.21 | 5.47 |
| 2015 | 615 | 40 | 13.55 | 5.89 |

Source: WAEC

From the table, there was a steady increase in number of students enrolling for WASSCE chemistry in these selected schools from 2011 to 2015 but the performance in practical examination remained consistently poor with mean scores of less than 15 out of 40. Candidates have shown certain weaknesses in chemistry practical examination as reported by WAEC chief examiner's report (2014, 2015); as follows:

1. inability to follow instructions hence ending up with wrong observations
2. inability to make correct inferences. This was particularly so even in areas they were able to make and record correct observations
3. inability to manipulate and obtain simple relationship between quantities of substances to arrive at quantitative results
4. inability to write correct formulae of ions
5. inability to write correct units for concentrations
6. inability to draw titration tables
7. inability to use mole concept to solve problems posed in the quantitative analysis.
8. Alteration and cancellation of titre values.

Based on these weaknesses, WAEC chief examiner's report recommends the following:

1. students need to be exposed to many practical work to enable them acquire the requisite practical skills.
2. Candidates should be taught how to write correct tests, make concretes observations and inferences.

### 1.3 Statement of the Problem

Chemistry is a practical subject which is concerned with the study of matter and its transformation through such processes as heating, electrolysis and other chemical processes (Twoli, 2006). For purposes of teaching and learning, chemistry is divided into two main components: theory and practical at the senior high level.

The emphasis on the theory component for students is on the acquisition and processing of knowledge in the form of facts, concepts, and laws/principles. In most cases this theoretical aspect of chemistry presents students with concepts and principles that are abstract making it difficult for them to concretise. The use of practical work in teaching therefore is to help in making the theoretical aspect of chemistry concrete.

Practical work in chemistry is carried out mainly in a laboratory where learning may be done through experimentation, observations and manipulation of equipment and materials. Thus, a laboratory is supposed to provide the concrete materials from which students can understand abstract concepts in chemistry and other science subjects. It is also a place where students are supposed to develop many manipulative and cognitive skills otherwise known as scientific skills and derive much enjoyment in learning chemistry.

The attainment of these goals may however depend on the students' active participation in the laboratory work/experiments which is determined by proper use of laboratory tools such as equipment or apparatus, materials and chemicals and the execution of correct procedural techniques. Effective participation can only be obtained if students practise the various scientific skills to desired levels safely in the laboratory, guided by the teacher. A chemistry teacher, therefore, becomes a key person in ensuring proper practical work management for effective learning.

Poor performance in practical work in chemistry might mean that the practical experiences were not properly planned and managed for students or that process and manipulative skills were not practised to the desired levels. If such a trend is allowed to continue, then students' ability to acquire the various scientific skills would be affected negatively. This would in turn affect students' further education and or training negatively.

**1.3.1 Purpose of Study**

This study sought to determine factors contributing to poor performance in practical work in chemistry. Based on the findings, recommendations were made that were anticipated would guide practice leading to enhanced performance in practical work in chemistry in particular and science in general.

## 1.4 Objectives of the Study

The objectives of the study were:

a) to identify factors that contribute to the poor performance in chemistry practical work in senior high school

b) to determine the skills acquired by students in practical lessons.

## 1.5 Research Questions

The study sought to answer the following questions:

i) what is the state of laboratories in the four selected schools?

ii) what skills are emphasised by teachers in teaching chemistry practical work in senior high school?

iii) what skills are assessed by teachers in practical work in chemistry at senior high school?

## 1.6 Significance of the Study

The findings of this study could:

1. provide a framework for teachers on which they could re-evaluate their instructional strategies during practical work in chemistry for the enhancement of effective teaching and learning.

2. provide insight for the curriculum designers into the kind of practical experiences students in secondary school chemistry need to aid sound understanding of scientific concepts and principles.

3. provide a framework for the WAEC on which the council could re-evaluate their goals and objectives so that the practices in the laboratory are in line with what the curriculum demanded of students

4. be an eye opener for teacher trainers so that appropriate strategies are put in place for the enhancement of adequate teacher preparation during pre and in-service training in chemistry.

Apart from adding to the existing body of knowledge, concerning practical work in chemistry, the results of this study could also stimulate more research.

**1.7 Limitations**

The study had the following limitations:

i) It was not possible to generalise the results to the whole country since the study was conducted only in a few selected senior high schools in the four selected regions.

ii) It was not possible to generalise the results to chemistry since only the practical aspect of senior high school chemistry was considered in this study.

**1.8 Basic Assumptions of the Study**

This study was dependent on the following assumptions:

i) that the teachers understood what practical work in senior high school chemistry entails and that they were able to arrange for practical work in chemistry for students.

ii) that by the time students get to Form Three, their attitudes towards the subjects they had opted to pursue would have stabilised and therefore could easily be projected.

iii) that the scores students obtained in WASSCE chemistry practical examination were a reflection of their competence in chemistry practical work

# CHAPTER TWO

# LITERATURE REVIEW

## 2.0 Overview

The review of related literature was done under four sub-headings: the learning environment during practical work in chemistry, the role of practical work in science teaching and learning, assessment of practical work in chemistry and related studies done in Ghana.

## 2.1 The Learning Environment and Practical Work in Chemistry

Chemistry is one of the subjects which present students with a large number of abstract ideas because it deals with mainly invisible concepts such as atoms, molecules, ions among others. One way to unlock the abstract concepts for students is by providing them with experiences that can aid understanding. Such experiences may be carried out in a laboratory.

However, White in Woolnough (1991) cautions that 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. White (1982; 1989), indicated that people remember vivid events that strike their attention. The study suggested that unusual and striking incidents need to be planned for deliberately in the laboratory. He observed that such incidents do occur but they are mostly unplanned accidents from which very little useful learning may be realised.

In many countries, over the last few decades, science has been taught at least in part by involving students in teacher-guided activity-based lessons. Through such activities, students are expected to develop their investigatory skills through experimentation to develop sound scientific knowledge (Woolnough, 1991). Tamir and Lunetta (1981) determined that, 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. However, their study identified a number of deficiencies with regard to practical experiences provided for during practical work as follows:

First, students were not given an opportunity to identify problems or to formulate hypotheses. Secondly, there were relatively few opportunities to design observation and measurement procedures. Thirdly, there were even fewer opportunities for students to design experiments and to work according to their own design. Fourth, students were not encouraged sufficiently to discuss limitations and assumptions underlying their experiments. Fifth, students were not encouraged to share their efforts even in the laboratory activities where that was appropriate. Finally, there were no provisions for post laboratory discussion, consolidation of findings and analysis of their meaning (Woolnough, 1991).

Tasker (1981) reveals that senior high school students saw little connection between practical work classes and other science lessons. In other words, students just followed instructions without thinking about the activities.

> ***Tasker:*** *What have you decided it ?(the activity/ task) is* ***about****?*
> ***Pupil:*** *I don't know, I never really thought about it……. just* ***doing*** *it- doing what it says….. it is 8.5….. just got to do different numbers and the next one we have to do is this one (points in text to 8.6).*
> (Tasker 1981)

Studies of learning styles (Baird and White 1982a; 1982b) indicate that the idea of students following instructions without thinking is not unusual. A study by (Berry et al., (1999a; 1999b) on students' perceptions of the purposes of laboratory work further confirms that many of secondary school students did not know why they did laboratory work.

This study sought to establish whether the opportunities offered to students during practical work in chemistry were those that enhanced development of various scientific skills.

### *2.2.1 The Role of a Chemistry Teacher in Practical Work*

Research has shown that, when you mention science lessons to students and they think of laboratories. Some do so with delight, others with absolute horror (Gastel, 1991). The range of reactions may result in part from the differences in learning styles and may also reflect the wide variability in quality of teaching. Johnstone (1997) identifies three basic components of modern chemistry; the *macro-chemistry* of the tangible, edible and visible, the *sub-microchemistry* of the molecular, atomic and kinetic and the *representational-chemistry* of symbols, equations, stoichiometry and mathematics, as represented in fig 2. 1

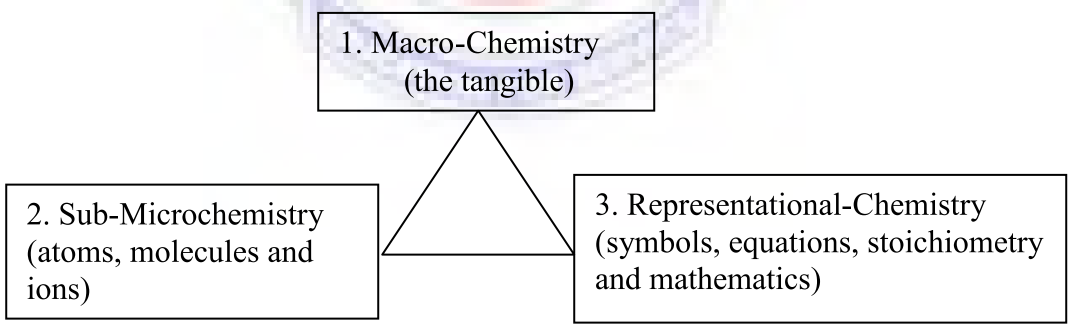



*Figure2. 1: Components of Chemistry Knowledge*

Source: Adapted from Wilson, 1999

According to Johnstone (1997), a teacher operates inside the triangle represented in figure 2.1. For him, this may pose problems for students if careful planning and preparation prior to teaching is not done. This is because chemistry lessons frequently introduce abstract concepts alongside complicated laboratory procedures to students. The teacher therefore needs to be aware of the potential difficulties students have with some chemical concepts for him/her to carry out role effectively (Wilson, 1999).

Although recent developments in science education advocate for inquiry-based approach where the students find out things for themselves through their own effort, most students know that the teacher knows the answer even if she/he does not. As a result, they typically look to the teacher to tell them if what they saw was ‘supposed to happen’, and to confirm that their data are right (Wellington, 1981). Following the above arguments, the teacher undoubtedly has a role to play in realising the potential of the laboratory. S/he needs to plan carefully, integrate the laboratory work with other instructional strategies and motivate students for effective teaching and learning. Unfortunately, as Woolnough and Allsop put it:

> Most science teachers have themselves been brought up on a diet of content dominated cookbook-type practical work and many have got in the habit of propagating it themselves (Woolnough and Allsop, 1985 ).

Tobin and Gallagher (1987) found that science teachers rarely, if ever, exhibit behaviour that encourages students to think about the nature of scientific inquiry and the meaning and purposes for their particular investigation during laboratory activities. Gunstone and Champagne (1990) suggested that meaningful learning in the laboratory would occur if students were given sufficient time and opportunities for interaction and reflection. According to the study, students generally did not have time or opportunity to interact and reflect on central ideas in the laboratory since they are usually involved in technical activities with few opportunities to express their interpretation and beliefs about the meaning of their inquiry. In other words, they had few opportunities for *metacognitive* activities:

> …these metacognitive skills are "learning outcomes associated with certain actions taken consciously by the student during a specific learning episode" (Baird, 1990 )

Metacognition involves elaboration and application of one's learning, which can result in enhanced understanding. The challenge is to help students take control of their own learning in the search for understanding. Thus it is vital to provide opportunities that encourage students to suggest hypotheses, design investigations - "minds-on as well as hands-on" and ask questions. According to Cuccio-Schirripa and Steiner (2000), questioning is one of the thinking skills which is structurally embedded in the thinking operation of critical thinking, creative thinking and problem solving. Therefore, other than providing students with frequent opportunities for feedback, reflection, and modification of their ideas (Barron et al., 1998), there is the need for teachers to create effective learning environments in which students are given opportunities to ask relevant and scientifically sound questions in an attempt to develop scientific literacy among them (Penick et al., 1996).

Research has also suggested that while laboratory investigations offer important opportunities to connect science concepts and theories discussed in the classroom and in textbooks with observations of phenomena and systems, laboratory inquiry alone is not sufficient to enable students to construct the complex conceptual understandings of the contemporary scientific community. "If students' understandings are to be changed towards those of accepted science, then intervention and negotiation with an authority, usually a teacher, is essential" (Driver, 1995). Teachers should thus emphasize the scientific aim of a laboratory task and make students aware of its purpose if worthwhile learning is to be achieved. All these led to Osborne and Freyberg (1985) describing the teacher as a motivator, diagnostician, guide, innovator, experimenter and researcher.

### *2.2.2 The Role of the Student during Practical Work in Chemistry*

One primary reason for learning is to comprehend the world. As such the brain actively seeks, selects, acquires, organises, stores and at appropriate times retrieves and utilises information about the world (Smith, 1975).

> *The world presents to the student and the scientific investigator a virtually unlimited amount of data…. the task of the student or the investigator is to screen out all the irrelevant data and consider only that which is pertinent to the problem at hand.* *(Egen et al 1979)*

Practical work in chemistry is a rich source of data that can be presented to the student because changes in colour or appearance may be observed, different sounds heard, different smells noticed and changes in temperature felt. However, Hudson in Levinson (1994) cautions that the practical work activity should not be a sit and watch demonstration or a recipe practical - that do not promote intellectual or cognitive skill development. Millar (2004) agrees with him, and concerning his view on teaching learning process, he wrote

> *Abstract ideas cannot simply be transferred from teacher to student; the student must play an active role in appropriating these ideas and making personal sense of them.*
> *(Millar, 2004 )*

Constructivism views learning as a process in which the student actively constructs or builds new ideas or concepts based upon current or past knowledge (Driver and Bell, 1985). The success with which a student is able to construct his/her own knowledge depend on their prior knowledge and attitudes. According to Ausubel (1968), the most important single factor influencing learning is what the student already knows. Attitudes towards learning have been the centre of focus in research for a long time. Schibeci, (1984); Khor, (1987). In all these studies, there is consensus that a positive attitude is a requirement if learning has to be accomplished.

### *2.2.4 Performance in Chemistry*

Performance in science and chemistry in particular has occupied the centre stage in research for a long time . APU, (1984); Kelly (1978, 1981); Murphy and Gott (1984); Bell, (1997); Gorard et al., (2001). Although the focus has been mainly on differential performance of girls and boys, the high volume of this research had been necessitated by the apparent low performance by students in science compared to other subjects. A number of reasons have been given for the poor performance by students in science namely: attitudes, prior knowledge, differences in learning abilities among others.

**a) Attitudes**

Attitude has been defined differently by different people but all of them seem to agree generally that, attitude refers to a state of mind. Attitudes are a way of thinking or feeling about something or somebody usually reflected in a person's behaviour when s/he reacts towards or against some situation, person, or object in a particular manner. Studies have shown that a positive attitude is a requirement if learning has to be accomplished . Schibeci, (1984), Khor, (1987). Schibeci and Riley, (1986) in their study, however showed that students' attitudes towards science are strongly influenced by what the teacher does in class, of which Henderson et al., (2000) agrees. According to Henderson et al., (2000), many aspects of a teacher's interpersonal behaviour and the laboratory learning environment are associated with a student's attitudinal outcomes. In line with the above, he stated that;

> *A teacher's strong leadership, provision of a degree of student responsibility and freedom and integration of practical and theory components of the course are likely to promote performance whereas a greater degree of strict behaviour by the teacher, emphasis on rule clarity and open-ended approach to the course are negatively associated with student performance.*
> *(Henderson et al., 2000 )*

It is for this reason that most science educators agree that the development of a positive attitude towards science should be an important goal of the school curriculum (Laforgia, 1988).

**b) Prior Knowledge**

According to Ausubel (1968) the most important single factor influencing learning is what the student already knows **(**prior knowledge**)**. According to Driver, (1983) as well as Osborne and Freyberg, (1985), students enter science classrooms already holding personally constructed ideas and beliefs which are often conflicting with the tenets of science. Examples of such personally constructed ideas and beliefs, include: boiling water decomposes to form hydrogen and oxygen, sugar disappears when added to water and stirred and sodium chloride dissolves in water to form a solution whose mass is less than that of the original sodium chloride and water. Practical work can therefore challenge these, if the students are given an opportunity to express their views in advance.

**c) Learning styles and abilities**

While studies have shown that it is possible to have students who merely followed directions when carrying out practical work, (Baird and White, 1982a, 1982b, Baird, 1986). Other studies also show that better learning styles can be encouraged (Paris et al., 1984, Baird and Mitchell, 1986). Such learning styles are those that enable the students to achieve meaningful (learning that enhances understanding). Better learning styles enhance students' responsibility for their own learning and may bolster performance.

## 2.3 The Role of Practical Work in Science Teaching and Learning

Science education in many countries aims at:

1. helping the students to gain an understanding of much of the established body of scientific knowledge as appropriate to their needs, interests and capacities and
2. developing students' understanding of the methods by which this knowledge has been gained, and grounds for confidence in it (knowledge about science) (Millar, 2004)

As such practical work in science education has taken a centre stage in all countries in the world and enormous resources are channelled towards it. Some of the reasons for inclusion of practical work in science teaching-learning arose out of the works of people considered as the main conceptual leaders of curriculum reform, such as Bruner(1966), Ausubel,(1968) Gagne(1970), Schwab(1960), Piaget and Karplus (Woolnough, 1991). From their works five major reasons were offered as rationale for inclusion of practical work in school science and more so, if carried out in the laboratory. First, science involves highly complex and abstract subject matter. As such many students would fail to comprehend such concepts without the concrete experiences offered by practical work.

Secondly, students' participation in actual investigations, employing and developing procedural knowledge often referred to as skills, is an essential component of learning science as an inquiry (Schwab 1960; 1962). It gives students an opportunity to appreciate the spirit of science and promotes problem solving, analytic and generalising abilities (Ausubel, 1968). It also allows the student to act like a real scientist (Bruner, 1966) and to develop important attitudes such as honesty, readiness to admit failure and critical assessment of results and limitations better known as scientific attitudes. Thirdly, practical experiences whether manipulative or intellectual, are qualitatively different from non-practical experiences and are essential for the development of skills and strategies with a wide range of generalizable effects (Gagne, 1970).

> *The skills are, in essence, learning tools essential for success and even for survival. Hence if you help students improve their use of these creative thinking skills, you have helped them become more intelligent and helped them learn how to learn*
>
> *(Lawson et al 1989 )*

The fourth is that, the laboratory has been found to offer unique opportunities conducive to the identification, diagnosis and remediation of students' misconceptions (Driver and Bell, 1985). Finally, students usually enjoy activities and practical work when they are offered and given a chance to experience meaningful and non-trivial experiences, they become motivated and interested in science (Henry, 1975; Lawson et al, 1989). It is with this understanding that UNESCO (1973) reiterated, "if school science is to be learned effectively, it must be experienced".

This means that, practical work plays an important role in the teaching/learning of science. A number of studies have been undertaken to determine the role of practical work in school science, (Woolnough and Allsop 1985, Hodson, 1990). Although the studies have summarised their findings differently, there is consensus however for all of them concerning the role of practical work in school science. Thus according to these studies, the purpose of practical work in school science is to:

1. teach laboratory skills

2. enhance the learning of scientific knowledge
3. give insight into the scientific method and develop expertise in using it
4. develop certain scientific attitudes such as open-mindedness, objectivity and willingness to suspend judgement
5. motivate the students by stimulating interest and enjoyment

As such, expectations of practical work are very high indeed. Besides helping students to develop conceptual and procedural understanding, it is also intended to have a motivating influence on them and help them appreciate what it means to be a scientist.

Millar (2004) identified two 'domains' of knowledge: the domain of objects and observable properties and events on one hand, and the domain of ideas on the other as shown in fig 2.2.

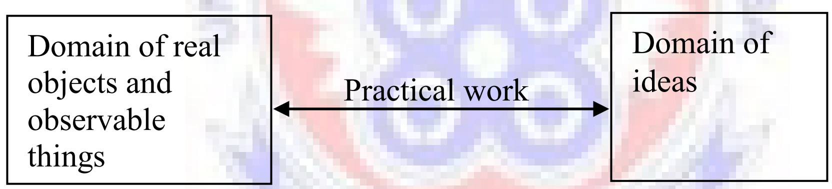



*Figure 2:Practical work linking two domains of knowledge*

Source: Adapted from Millar,( 2004)

According to Millar (2004), practical work helps students make links through reflection between these two 'domains' of knowledge which leads to understanding.

> *Students need to observe objects and phenomena in order to have a basis of experience on which to reflect. Without first hand, practical experience of the world it is hard to see how a student could ever come to an understanding of it*
> *(Millar 2004 )*

Shayer and Adey (1981) also said the concrete approach offered by practical work as the best for tackling new topics. This is based on Piaget's level of intellectual development. Students learn better when they can see what they are being taught.

Practical experiences offer opportunities for students to work cooperatively with one another, which promotes understanding. Hofstein and Lunetta, (1982) and Lazarowitz and Tamir, (1994) suggested that, laboratory activities have the potential to enhance constructive social relationships as well as positive attitudes and cognitive growth. The social environment in a school laboratory is usually less formal than in a conventional classroom; thus, the laboratory offers opportunities for productive, cooperative interactions among students and with the teacher that have the potential to promote an especially positive learning environment which is essential for understanding.

From the foregoing discussion, it is evident that practical work in science in general and chemistry in particular presents the student with the stimulus to aid understanding of scientific knowledge. Most of the research on the role of practical work in science teaching has been done outside Ghana. I agree with the roles outlined above concerning practical work and believes that if properly managed, practical work can achieve most of its objectives and aid in understanding of scientific knowledge. However, the concern for this study was to establish whether teachers in the selected schools were aware of these roles and whether the activities they presented to students in practical work in chemistry were geared towards enhancing the achievement of these roles.

### 2.4 Assessment of Practical Work in Chemistry

If truly laboratory activities are used to accomplish a variety of goals such as the acquisition of both manipulative and process skills together with positive attitudes, then evaluation of these skills and attitudes should find their way in assessment procedures. According to Orwa and Underwood, (1986), assessment procedures need to be devised to measure mastery of content, performance in process skills and development of desirable scientific attitudes. They went further and stated that observing students during their regular school scientific activities provides a more reliable way of assessing process skills. Giddings et al (1991) on the other hand claimed that assessment of students' behaviours in the laboratory should include planning and designing, implementing, analysing and interpretation of data and application of laboratory techniques to new problems. This is because written laboratory work does not provide information about student's skills in manipulating equipment, observing, organising and performing an investigation creatively and efficiently. Twoli (2006) in an agreement with all these, said;

> *'Most of the conventional practical tests are done and reported individually. A candidate performs and reports or records on paper for the examiner to assess. The examiner can only assume that the skills were utilised during the practicals to give the product on the paper (Twoli, 2006 ).*

One of the reasons given for lack of proper assessment procedures is that teachers lack experience with assessment methods aimed at assessing their students' understanding and performance in the science laboratory (Yung, 2001). As a result, in many cases, students' final grades do not include a component that directly reflects their performance in laboratory work and their understanding of that work.

The assessment of practical work in chemistry and other science subjects in national examinations at the senior high school level in Ghana consists of a practical examination designed to test the candidates' ability to apply knowledge, to utilise skills in carrying out experiments and evaluate experimental results and observations. In chemistry, the questions are set from any section of the syllabus and for a candidate to obtain a credit in chemistry s/he must pass in the practical examination (WAEC, 2010). While this condition by WAEC (2010) shows the importance attached to practical work in science and chemistry in particular, it could have implications on how practical chemistry is taught and assessed in schools. For example, teachers could focus only on certain aspects of practical work as assessed by WAEC.

The concern of the present study is to determine whether teachers assessed all skills of students in practical work in chemistry, the skills assessed and if the marks obtained form part of the Continuous Assessment Tests (CATs) for students. .

## 2.5 Resources and facilities for teaching practical work in chemistry

Teaching/learning resources are important in the teaching/learning process because they help in concretising abstract knowledge hence aid in understanding. Unlike Majan (1989) whose study revealed inadequacy of teaching/learning resources, the results of this study revealed that schools in the study sample were well equipped with apparatus and materials to enable students engage in a variety of activities in practical work in chemistry. The students were indeed involved in actual practical work in chemistry as revealed by this study. This is in line with UNESCO (1973), that "if school science is to be learned effectively, it must be experienced". Also, the results of this study agree in part with Musoko (1983) whose study revealed that laboratories were available for use in teaching another science subject; physics, only that the availability of laboratories was not translated into use for teaching practical work in the subject. Instead, the laboratories were largely used as classrooms. From the results of this study, it can be said that it is not just enough to have teaching/learning resources; the resources need to be put to effective use in ways that capture students' attention so as to aid understanding of scientific concepts.

**2.6 Skills emphasized in teaching and assessment of practical work in chemistry**

A number of skills associated with science and chemistry in particular have been documented. According to Weld (2004), scientific skills may be categorised into two main forms; **basic process skills** and **integrated process skills.**

Basic process skills include observing, classifying, measuring, communicating, inferring and predicting while integrated process skills include experimenting, formulating hypothesis, collecting and representing data, interpreting and analysing data and making conclusions. Just like Tamir and Lunetta (1981), the results of this study revealed that opportunities were offered to students that enabled them to engage in a variety of practical work activities in chemistry. However, the extent of emphasis of skills in teaching and assessment of practical work is mainly in the basic process skills category. The skills emphasised included observation and manipulation of apparatus and materials. Emphasis of skills in the integrated category such as hypothesis formulation and experimenting were found to be lacking during practical work sessions in chemistry. Lack of emphasis of process skills in the integrated category during practical work in chemistry denied students vital opportunities to take control of their own learning which could lead to enhanced understanding.

Emphasis on basic process skills encourages students to follow instructions in worksheets without thinking about what they were doing. By the time students got to the external practical examination in chemistry, they would probably have forgotten such procedures. For those who would be able to carry out the procedures, they would probably not be able to attach meaning to the results obtained hence the observation by WAEC (2012, 2013) that "some students were unable to make correct inferences even after making correct observations".

**2.7 Attitudes of teachers and students towards practical work in chemistry**

Studies have shown that a positive attitude is a requirement if learning must be accomplished. Schibeci (1984) and Khor (1987). The results of this study revealed that both chemistry teachers and students generally had positive attitudes towards practical work in chemistry. One of the reasons that could be given for the lack of reflection of positive attitudes in performance of practical work in chemistry would be that students failed to make links between the practical activities they carry out in chemistry and the theory behind them. This was likely to be the case, based on the view held by students that practical work in chemistry was something to fall back to whenever they did not understand content taught during theory lessons.

**2.8 Summary**

From the reviewed literature, it is clear that practical work has a role to play in the teaching and learning of science in general and chemistry in particular. The role of practical work may be realised if practical activities are planned and managed or presented to the students in ways that enhanced the acquisition of the various scientific skills. In this regard, the chemistry teacher becomes a key factor. The ways in which s/he organises practical work in chemistry and whether the activities help in acquisition of a variety of scientific skills this becomes the focus in this study.

# CHAPTER THREE

# METHODOLOGY

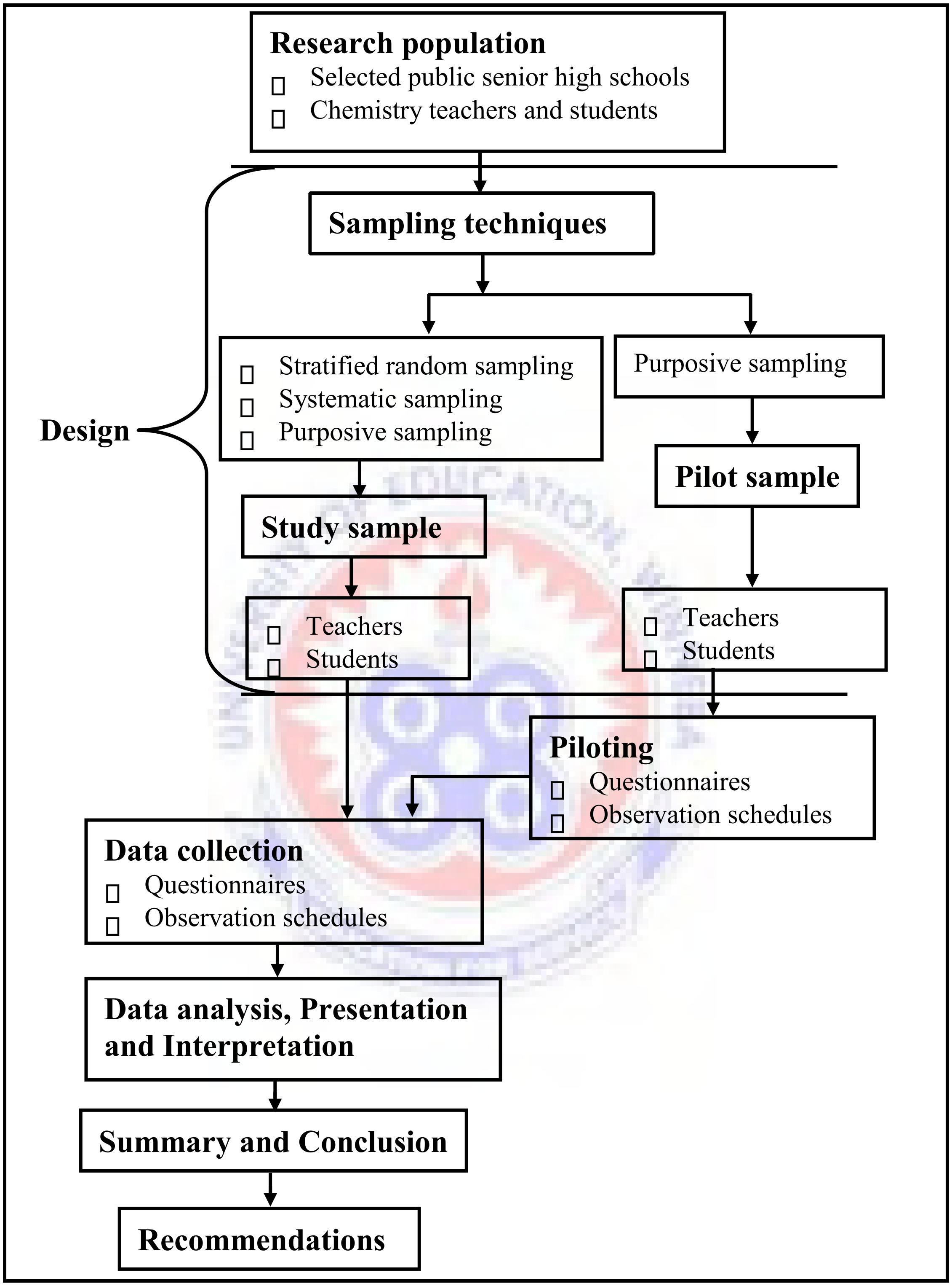
## 3.1 Overview

This chapter focuses mainly on the following areas: research design, the target population and sample for the study, research instruments, data collection procedures and logistical and ethical considerations.

## 3.2 Research Design

This study employed a survey design. Survey studies are usually utilised to investigate phenomena in their natural settings (Koul, 1984). They allow the use of a variety of data collection instruments such as questionnaires, observation schedules and document analysis among others. In using questionnaires in this study, it was easy to obtain both qualitative and quantitative data from teachers and students with regard to existing status of practical work in chemistry especially in terms of skills acquired. From the lesson observation schedules, the behaviour and skills emphasised during practical work in chemistry were captured.

The design embraced the descriptive approach since data gathered was used to describe the existing status of practice of practical work in senior high schools, the procedure of conducting practical work in chemistry and how the practice and procedure influenced performance in practical work in chemistry. The summary of the design and process of study is given in fig. 3.1




Source: Adapted from Cohen and Manion, 1994

*Figure 3: A survey research design and process for the study*

### 3.2.1 Variables

**Independent variable**

This is the variable that predicts the amount of variation in another variable (Mugenda and Mugenda, 1999). The independent variable in this study was practical work in chemistry in senior high schools. The study sought to determine how practical work was conducted in senior high school chemistry by establishing the roles played by both teachers and students during practical work. The choice of practical work activities, the way they were presented to students and students' engagement in them was presumed to be influenced by a number of factors such as **teacher factors,** such as experience, training, attitudes and teaching style, **school factors,** such as resources and school type and **students' factors** such as attitudes and learning styles.

**Dependent variable**

This is the variable that attempts to indicate the total influence arising from the effects of an independent variable (Mugenda and Mugenda, 1999). The dependent variable in this study was performance in chemistry practical work. Performance in chemistry practical work was presumed to be influenced by the type of practical activities, the way the activities were presented to students and students' engagement in the activities.

## 3.3 Location of Study

The study was conducted in four regions of Ghana. The four selected regions were chosen for the study because of high multicultural population density. As such, it was not a problem accessing schools and getting adequate representation study sample. Also, schools in these selected schools are close in proximity which helped to reduce the operation costs and allowed for efficient management of research time.

## 3.4 The Target Population

The selected regions have two groups of schools: public and private. The population from which the sample was drawn comprised only the public schools in the selected regions. Public schools were chosen for this study because of the uniform curriculum offered in such schools and the fact that teachers in the schools were posted by the Ghana Education Service and therefore were qualified and permanent teachers. The chemistry syllabus used in teaching is the same for all the schools. Likewise, the assessment modes used were presumed to be the same. Also, in private schools most of the teachers there are part time teachers. Some are diploma holders and others are certificate holders. The few permanent and degree holders were retired teachers from public schools. It was for these reasons that private schools did not form part of the population and sample in this study.

The study involved third year chemistry students because they had chosen to pursue chemistry to the WASSCE level, hence their attitudes towards the subject had stabilised and could be projected easily. First year and second year students were considered unsuitable because they had not learned enough chemistry to be able to comment comprehensively on matters relating to practical work in chemistry

The study also involved chemistry teachers in public senior high schools in the regions. It was anticipated that these teachers were aware of the role of practical work in the teaching/learning of chemistry and that they would be able to conduct chemistry practical sessions for students.

### 3.5 Research Instruments

The main instruments used in this study were:

i) Chemistry teachers' questionnaire (CTQ)

ii) Chemistry students' questionnaire (CSQ)

iii) Lesson observation schedule (LOS)

iv) Document analysis guide (DAG)

#### i) Chemistry Teachers' Questionnaire (CTQ)

This instrument (Appendix 1) was used to collect information from the chemistry teachers in the sample schools. It was chosen mainly because of its objectivity. Most of the items in this instrument were closed-ended. This allowed for objective analysis of the data collected. However, some sections of the questionnaire contained open-ended items which allowed teachers to give free responses and hence enabled me to exhaustively gather a lot of information ranging from facts to opinions both in qualitative and quantitative forms. This questionnaire was an adapted form of the teachers' questionnaires used by Musoko (1983) and Iraki (1994).

**ii) Chemistry Students' Questionnaire (CSQ)**

This instrument (Appendix 2) was used to gather information from students in the sample schools. The information gathered using this instrument were basically opinions of students regarding practical work in chemistry. This questionnaire was an adapted version of students' questionnaire used by Iraki (1994).

**iii) Lesson Observation Schedule (LOS)**

Practical work experiences in chemistry were observed, using a lesson observation schedule (Appendix 3). This instrument helped to get first-hand information regarding the experiences arranged for students during chemistry practical work in the senior high school. I was concerned with the skills (both manipulative and cognitive) emphasised during practical work in chemistry. In this regard, the skills were coded as behaviour and recorded in a sequential order as they occurred within every minute. The LOS also focused on safety aspects during practical work in chemistry to determine whether the teachers drew the attention of students to safety rules. The observation schedule was an adapted version of the one used by Musoko (1983).

**(iv) Document Analysis Guide (DAG)**

Chemistry teacher questionnaires (CTQs) from each sample school were analysed with regard to the skills teachers assess in chemistry practical work and skills emphasised in teaching chemistry practical work and the results compared with skills assessed by WAEC for any trends.

### 3.6 Pilot Study

A Pilot study was conducted to determine the timing and suitability of the instruments. Four averagely performing schools were purposely selected, each from a region to capture uniformity in performance across the four schools. The pilot study involved 4 chemistry teachers and 100 third year chemistry students, who responded to the questionnaires. The schools that had participated in the pilot study were not considered in the sampling of schools for the main study. Before administering the instruments, permission was sought from the school administration. Arrangements were then made for lesson observation and the administration of the questionnaires. The data collected was coded and analysed which led to modification and adoption of the instruments. The sampled schools were West Africa senior high school in Greater Accra region, Assin North senior high school in Central region, Somenya senior high school in Eastern region and Aveyime senior high school in Volta region.

#### *3.7.1 Validity of Research Instruments*

Validity is a measure of the degree to which a research instrument measures what it is supposed to measure. In determining the validity of the instruments, the opinions of experts were sought. The experts included the supervisor and chemistry teachers currently teaching chemistry. The pilot phase also helped in validation of these instruments, particularly in determining the clarity of items and level of language.

### *3.7.2 Reliability of Research Instruments*

Reliability is a measure of the degree to which a research instrument yields consistent results or data after repeated trials. Reliability of the CTQ and the CSQ were ascertained during the pilot phase of the study.

## 3.8 Data Collection Techniques

Before administering the instruments, permission from the head masters/mistress of the schools in the study sample was sought. I went ahead and established a working relationship with the chemistry teachers. This was a crucial stage in this study because it was during this time that I obtained the teachers' consent to participate in the study. The teachers' consent depended on the rapport established and the teachers' confidence in me. Teachers' consent, teachers' confidence and rapport between me and the teachers all worked to ensure the success of this study. All through, the school administration, teachers and students were assured that the data collected would not be used for any other purposes other than this study and that it would be treated with strict confidence. The appropriate time for administering of students' questionnaires was then negotiated. It was anticipated that the presence of a chemistry teacher in the room would have had an effect on the students' responses. I requested the chemistry teachers to complete the CTQ on the day of visit. The completed CTQs were collected. For lesson observation, the normal running of the school was not interrupted, by observing the lessons as they appeared on the school's timetable. Timetables for practical work were requested for, from the teachers during the familiarisation visits. These enabled to prepare a visitation schedule to the schools. To avoid the teacher making any specific preparations, no special appointments were given. To minimise the observer effects on both the teachers and students, familiarisation visits during practical work in chemistry were arranged. During such visits, I sat at the back of the room and did not record anything. This made both the teacher and the students to be at ease. The number of such visits was limited to two. During the familiarisation visits and actual observation, the researcher entered the room with the teacher to avoid interrupting the lesson in anyway. To supplement the direct observation of practical work lessons, the researcher also tape recorded the lessons with permission from the chemistry teacher. The audio tape was used to record the verbal interactions that were going on in the class. It was realised during the pilot study that soon after the teacher introduced the practical activity to students they would go to their various groups and start working. During that time, the recorder could only record noise. Therefore, during the main study, the researcher switched it off until the teacher reconvened the students for discussion of experimental results. The audio tape was replayed later after the lesson to fill up any gaps that could have been omitted during direct observation.

# CHAPTER FOUR

# RESULT AND DISCUSSION

## 4.1 Introduction

Data collected using the instruments was analysed and the summary of the analysis presented in this chapter. The interpretation of the analysed data and discussion were also presented in this chapter. The main factors identified from the data instruments analysis were: resources for teaching and learning practical work in chemistry, skills emphasised during practical work in chemistry and attitudes of teachers and students towards practical work in chemistry.

This study was carried out in Ashanti region, Central region, Eastern region and Volta region which are only four out of ten regions of Ghana.

a) It was conducted in few selected senior high schools, namely: New Edubiase SHS, Assin North SHS, Somenya SHSand Aveime SHS and involved only four chemistry teachers from each of the selected school and few selected Form three students in the schools.

b) It focused only on the practical aspect of senior high school chemistry. It is however clear that the overall grade in WASSCE chemistry is a contribution of both theory and practical examination and given as a grade for performance in chemistry.

## 4.2 Data Presentation and Interpretation

The analysed data was presented using tables in most cases. The presentation and interpretation of the analysed data was done under the following headings: resources for teaching chemistry practical, behaviour and skills emphasised during chemistry practical work, type of practical work in chemistry, aims of practical work in chemistry, assessment of practical work in chemistry and attitudes of teachers and students towards chemistry practical work.

c) This study was carried out in Ashanti region, Central region, Eastern region and Volta region which are only four out of ten regions of Ghana.

d) It was conducted in few selected senior high schools and involved only four chemistry teachers from each of the selected school and few selected Form three students in the schools.

e) It focused only on the practical aspect of senior high school chemistry. It is however clear that the overall grade in WASSCE chemistry is a contribution of both theory and practical examination and given as a grade for performance in chemistry.

### 4.3.1 Resources for Teaching and Learning Practical Work in Chemistry

The CTQ was used to obtain information regarding resources for teaching and learning chemistry practical work. The study focussed mainly on laboratories, laboratory provisions and laboratory technicians.

#### a) The Laboratory

The laboratory is a key resource in teaching and learning science and chemistry in particular, where students can be engaged in a variety of activities. This study sought to establish the state of science laboratories in the selected schools. The results indicated that all schools in the study sample had at least one laboratory for teaching science with 78% of the schools having two or more science laboratories.

Table 4.1 shows the availability of laboratories in the sampled schools

*Table 2: Availability of Laboratories*

| | Number of schools |
|---|---|
| One lab for each of the three science subjects | 3 |
| Two labs for the three science subjects | 1 |
| One lab for the three science subjects | 0 |
| Two laboratories each for each of the three science subjects | 0 |
| Total | 4 |

For schools having two laboratories, it may be assumed that one laboratory was used for biology while the other one was used for physical sciences (chemistry and physics). For schools having more than two laboratories, it may be assumed that each of the science subjects had its own laboratory.

Having laboratories for teaching and learning of science is important, but in itself, is not enough, since the laboratories need to be equipped with the necessary apparatus and chemicals and put to use if they must aid in the acquisition of scientific skills by the students. This study revealed that laboratories in the sampled schools were with basic apparatus and chemicals to enable practical work in chemistry to be carried out as shown in Table 3

*Table 3:The main laboratory provisions*

| Laboratory provisions | Schools that had | Schools that did not have |
|---|---|---|
| Worked Benches | 2 | 2 |
| Stools | 2 | 2 |
| Apparatus (beakers, burettes, test tubes etc.) | 4 | 0 |
| Running water | 3 | 1 |
| Functional fume chamber | 0 | 4 |
| Chemicals' store | 4 | 0 |
| First aid box | 2 | 2 |
| Chemicals in stock | 4 | 0 |

Notably absent in some schools in the sampled schools were functional fume chambers and first aid boxes with 100% of the schools having no fume chambers and 50% of them without first aid boxes. These two facilities are important for ensuring the safety of laboratory users (students, teachers and laboratory technicians). A fume chamber is compartments built within the laboratory that allows experiments, which emit poisonous fumes are carried out in the chamber. It can also act as storage for chemicals that emit poisonous fumes. Lack of a functional fume chamber was likely to influence the type of practical experiences arranged for students. Thus, teachers were likely to overlook experiments that required its use. Experiments that require the use of a fume chamber include: preparation of gases such as chlorine, nitrogen (IV) oxide and sulphur (IV) oxide among others.

A chemistry laboratory is a place where there is a high likelihood of occurrence of accidents because of the nature of materials that are handled and stored therein. Such accidents may include: inhalation of poisonous fumes, burns from acids, cuts from broken glass among others. The first aid box, therefore, becomes handy in the event of such accidents. It contains materials that could enable a teacher or laboratory technician to give first aid to a victim before arrangements to take victim to hospital. Lack of a first aid box was likely to endanger the lives of laboratory users.

Chemistry teachers were also required to rate the adequacy of chemicals in terms of whether the chemicals could last the whole year or part of the year. From their ratings in Table 4, 22%, 78% of the schools had enough chemicals to last the whole year.

*Table 4: Adequacy of chemicals*

| | % |
|---|---|
| Schools that have chemicals to last a year | 78 |
| Schools that have chemicals to only part of the year | 22 |

**b) The Laboratory Technicians**

These are resource personnel whose main role is to ensure proper management of laboratories by assisting the science teachers with the preparations for practical work . In schools where laboratory technicians are available and trained, the preparation load on the teacher is minimised and hence s/he spends most of the time doing the actual lesson planning and consulting reference materials. Where there are no trained laboratory technicians, the teacher also doubles as a technician. This could greatly reduce the teacher's lesson planning time and lead him/her to go to class unprepared or poorly prepared practical session altogether.

This study sought to establish whether the schools had laboratory technicians. Table 5 shows in the number of laboratory technicians in sampled schools.

*Table 5: Number of laboratory technicians/assistants [ trained and untrained]*

| | Number of schools | Number of technicians | % of schools |
|---|---|---|---|
| One for each of the science lab | 1 | 3 | 49.98 |
| Two for the three science lab | 1 | 2 | 33.32 |
| One for all the three science lab | 2 | 1 | 16.66 |
| Total | 4 | 6 | 100.0 |

| | Number | % |
|---|---|---|
| Trained laboratory technicians | 4 | 66.66 |
| Untrained laboratory technicians | 2 | 33.33 |

From Table 5, all schools in the sampled had laboratory technicians with 16.66% of the schools having only one technician to manage all the three science labs. This was considered to be an overload on the part of the technicians which would most likely render them ineffective thereby calling on the science (chemistry) teacher to step in to assist.

Apart from the number of laboratory technicians, the study also established that 66.66% of laboratory technicians in sample schools were trained. Table 6 shows the number of trained and untrained laboratory technicians in sampled schools

The high number of trained laboratory technicians in the sample schools was a positive factor which could be emulated by all schools. This is because practical work in science and chemistry in particular requires a lot of preparations especially if the practical activity involves quantitative analysis. The solutions for such analysis need to be prepared according to specified concentrations. As such, if a laboratory technician was not trained, s/he would likely not be familiar with procedures for preparation of standard solutions which could lead to inaccurate results hence influence negatively to the acquisition of certain scientific skills.

### 4.3.2 Chemistry Teachers' Biodata and Skills emphasized during Chemistry Practical Work

The chemistry teacher plays an important role in practical work in chemistry because he influences to a great extent the behaviour and skills emphasised during practical work. Therefore, it was important that the biodata of chemistry teachers be obtained.

The biodata was collected using the CTQ and it included: the teacher's gender, professional qualification, level of academic qualification, chemistry teaching experience in years, number of chemistry lessons per week, total teaching load and second teaching subject. It was believed that some if not all of the above factors could contribute to the way a teacher arranged and even presented learning experiences to the students.

#### 4.3.2.1 Chemistry Teachers' Biodata

**a) Teachers' Gender**

The CTQ was administered to 4 chemistry teachers in sampled schools of which 75% were males while 25 % were females.

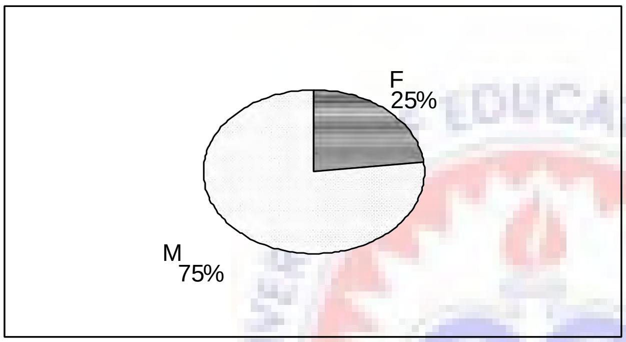



*Fig. 4.1: Chemistry teachers by gender*

**b) Professional Qualification**

*Table 4.6: Professional qualification of chemistry teachers*

| | Number of teachers | % |
|---|---|---|
| Diploma in Sc. Ed | 0 | 0.00 |
| B. Ed(Sc) | 3 | 75.0 |
| B. Sc with PGDE | 0 | 0.00 |
| M.Ed | 1 | 25.00 |
| | Number of teachers | % |
| Less than 2 | 0 | 0.0 |
| 2-5 | 0 | 0.00 |
| 6-10 | 1 | 25.0 |
| 11-15 | 3 | 75.0 |
| More than 15 | 0 | 0.00 |

The results of this study showed that all the chemistry teachers in the sample were professionally qualified with 75% of them having a B. Ed (Sc) degree, 25% of them having a M.Ed .Table 4.6 shows the professional qualification of the teachers

**c) Teaching Experience**

Chemistry teachers in the sample were found to be experienced in teaching chemistry with 75% of them having taught chemistry for more than 10 years. Experience of teaching a particular subject was an advantage because it could contribute to good mastery of content by a teacher. Table 4.7 shows the experience of teaching chemistry in years.

**d) The Teaching Load**

The average teaching load of chemistry teachers in sampled schools was found to be 22 periods per week. According to the TSC (2005), a teacher is considered fully utilised if s/he teaches not less than 27 periods per week. Therefore the chemistry teachers in the sample schools were not loaded with work than can be an excuses for not having enough time for chemistry practical works.

**e) Number of Chemistry Lessons**

Chemistry teachers were found not to be overloaded as far as chemistry lessons were concerned since 50% had up to 20 chemistry periods per week. Table 7 shows the number of chemistry periods per week for chemistry teachers.

### *4.3.2 Type of Practical Work in Chemistry*

Information concerning the type of practical work in chemistry was obtained using the LOS. The results indicated that practical work observed was mainly students' experiments. This represented 92% of all the practical work lessons observed in chemistry where students were working in groups with between 3 and 4 students. The remaining 8% was teacher demonstration. Table 4.8 shows the type of practical work done in secondary school chemistry

*Table 4. 6: Type of practical work*

| Type | Number of lessons | % |
|---|---|---|
| Students' experiment | 22 | 92 |
| Teacher demonstration | 2 | 8 |

Teacher demonstration is a practical experience that can be used as an alternative to students' experiment. The low percentage of teacher demonstration in chemistry was quite in order because demonstration as it has its own place in chemistry practical work. Some of the reasons that can be put forwards for carrying demonstrations include:

I. potentially dangerous materials/chemicals

II. delicate equipment/apparatus

III. shortage of equipment and materials

IV. showing a difficult skill among others

In this study, the first reason was found to apply, however what was worthy of commendation was the involvement of the students as the teacher carried out the demonstration. The students were involved in taking readings and the setting up of the apparatus. They were also required to observe and note the observations. Involvement of students during a demonstration enhances students' ability to take charge of their own learning. As Millar (2004) put it 'the student must play an active role in the learning process if he has to make sense of the ideas and concepts presented during the lesson.

#### *4.3.3 Aims of Practical Work in Chemistry*

Information regarding chemistry teachers' views on the aims of practical work was collected using the CTQ. The teachers were supplied with the various aims of practical work in chemistry and asked to rate the level of achievement of those aims during practical work as follows: 1=not at all, 2=to a small extent, 3=to a satisfactory extent, 4=to a large extent and 5=to a very large extent. Table 10 shows the ratings the teachers gave.

*Table 4.7:Aims of practical work in chemistry*

| | Aim | Frequency at each level of achievement | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Blank |
| i) | To teach basic practical skills | 0 | 0 | 1 | 1 | 1 | 1 |
| ii) | To familiarise students with standard apparatus and measuring techniques | 0 | 0 | 2 | 1 | 1 | 0 |
| iii) | To train students in making observations | 0 | 0 | 1 | 1 | 1 | 1 |
| iv) | To train students on recording observations | 0 | 0 | 2 | 1 | 1 | 0 |
| v) | To train students in making deductions and interpretations of experimental data | 0 | 0 | 2 | 1 | 1 | 0 |
| vi) | To use experimental data to solve specific problems | 0 | 0 | 1 | 1 | 1 | 1 |
| vii) | To train students in writing reports on experiments | 0 | 0 | 2 | 1 | 1 | 0 |
| viii) | To train students in simple aspects of experimental design | 0 | 0 | 1 | 1 | 1 | 1 |
| ix) | To arouse and maintain students' interest in the subject | 0 | 0 | 1 | 1 | 2 | 0 |
| x) | To show the use of practical work as a process of discovery | 0 | 1 | 1 | 1 | 1 | 0 |
| xi) | To verify scientific facts | 0 | 2 | 1 | 0 | 0 | 1 |
| xii) | To help bridge theory and practice | 0 | 1 | 0 | 1 | 1 | 1 |
| xiii) | To train students on how to raise and answer questions concerning scientific phenomena | 0 | 0 | 1 | 1 | 1 | 1 |
| xiv) | To train students on hypothesis formulation | 1 | 0 | 1 | 1 | 0 | 1 |

| | Aim | f | 2f | 3f | 4f | 5f | Total | Rank |
|---|---|---|---|---|---|---|---|---|
| i) | To teach basic practical skills | 0 | 0 | 3 | 4 | 5 | 12 | 5 |
| ii) | To familiarise students with standard apparatus and measuring techniques | 0 | 0 | 6 | 4 | 5 | 15 | 2 |
| iii) | To train students in making observations | 0 | 0 | 3 | 4 | 5 | 12 | 5 |
| iv) | To train students on recording observations | 0 | 0 | 6 | 4 | 5 | 15 | 2 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| v) | To train students in making deductions and interpretations of experimental data | 0 | 0 | 6 | 4 | 5 | 15 | 2 |
| vi) | To use experimental data to solve specific problems | 0 | 0 | 3 | 4 | 5 | 12 | 5 |
| vii) | To train students in writing reports on experiments | 0 | 0 | 6 | 4 | 5 | 15 | 2 |
| viii) | To train students in simple aspects of experimental design | 0 | 0 | 3 | 4 | 5 | 12 | 5 |
| ix) | To arouse and maintain students' interest in the subject | 0 | 0 | 3 | 4 | 10 | 17 | 1 |
| x) | To show the use of practical work as a process of discovery | 0 | 2 | 3 | 4 | 5 | 14 | 3 |
| xi) | To verify scientific facts | 0 | 4 | 3 | 0 | 0 | 7 | 7 |
| xii) | To help bridge theory and practice | 0 | 2 | 0 | 4 | 5 | 11 | 6 |
| xiii) | To train students on how to raise and answer questions concerning scientific phenomena | 0 | 0 | 3 | 4 | 5 | 12 | 5 |
| xiv) | To train students on hypothesis formulation | 1 | 0 | 3 | 4 | 5 | 13 | 4 |

When the levels of achievement of the aims were multiplied by the frequencies (f) and the totals worked out for each aim, results in Table 4.9 were obtained.

From Table 4.9, aims ix was rated highest while aims xi was rated lowest by the teachers. As observed from the results arising from the LOS.

### *4.3.4 **Assessment of Practical Work in Chemistry***

The CTQ provided information regarding the assessment chemistry teachers carried out in chemistry practical work in senior high school. While 100% of the teachers who participated in this study agreed that they assessed students in chemistry practical work, there was a wide number  regard to the level at which assessment begun, with 50% of the teachers beginning the assessment at Form three while 25% and 25% of them started the assessment at Form one and Form two respectively. Table 4.10 shows the levels at which assessment of practical work begin.

***Table 4.10: Levels at which assessment of practical work in chemistry begins***

| Level | Number of teachers | % |
|---|---|---|
| Form 1 | 1 | 25.00 |
| Form 2 | 1 | 25.00 |
| Form 3 | 2 | 50.00 |

As to whether marks students obtained in practical work formed part of the continuous assessment marks, 93% of the teachers agreed that they did.

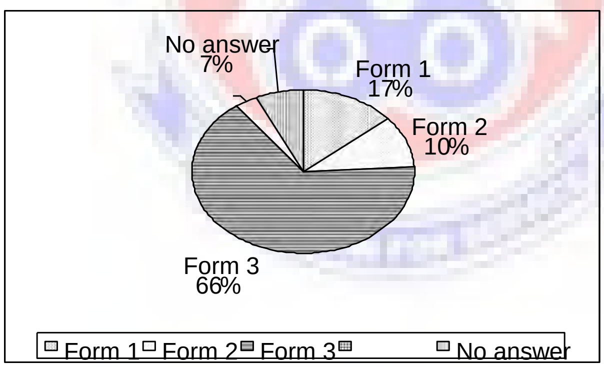



***Fig. 4.3: Levels at which inclusion of chemistry practical work marks in CATs begin***

From tables 4.17 and figure 4.3, teachers started being serious with assessment of practical work at Form three. That practice was likely to make students in the lower classes to view practical work in chemistry as an activity for examination purposes and not as a means of acquiring the various scientific skills. Such a view was likely to affect negatively the acquisition of various skills by the students.

The CTQ analysed for skills assessed by teachers, revealed that observation and manipulation of apparatus and materials topped the list with 75% and 50% respectively of the teachers assessing those skills. Other skills assessed were recording of data, data interpretation and inferring, in that order. Table 4.18 shows the skills assessed by the teachers and the respective percentages of the teachers who assessed them.

***Table 4.11: Skills assessed in chemistry practical work by teachers***

| Skill | Number of teachers | % |
|---|---|---|
| Observation | 3 | 75 |
| Manipulation | 2 | 50 |
| Recording of data | 3 | 75 |
| Interpretation of data | 2 | 50 |
| Inferring | 2 | 50 |
| Reading of instruments | 3 | 75 |

WASSCE chemistry practical past papers for the years 2011, 2012 and 2013 together with the WAEC syllabus were analysed to reveal the skills that were assessed by WAEC. The results of the analysis revealed that there was a correlation between the skills assessed by WAEC and those that were assessed by the teachers in the CATs. The correlation was that teachers assessed students in skills similar to those that were assessed by WAEC. That practice indicated that teachers engaged students in activities that enhanced mostly certain kinds of skills especially those that were related to the ones emphasised by WAEC. Lack of emphasis of skills such as experimental design could lead to inability to develop such skills by students.

### *4.3.6 Attitudes towards Practical Work in Chemistry*

This study sought to determine the attitudes of teachers and students towards practical work in chemistry.

**a) Teachers' attitudes towards practical work in chemistry**

Section C of CTQ utilised a five-point Likert scale in which the respondents were required to give their views regarding given statements as strongly agree (SA), agree (A), not sure (NS), Disagree (D) or strongly disagree (SD). Numbers were then assigned to the responses as follows: 1=SA, 2=A, 3=NS, 4=D and 5=SD for negative statements and 5=SA, 4=A, 3=NS, 2=D and 1=SD for positive statements. For easy presentation of analysed data each statement was coded as shown in table 4.12.

***Table 4.12: Statements on the Likert scale and their codes for CTQ***

| Statement | Statement type | Code |
|---|---|---|
| The chemistry teacher should carry out activities in chemistry practical work as the students sit back and watch | Negative | $N_1$ |
| Practical work makes the learning of chemistry difficult | Negative | $N_2$ |
| Examinations in chemistry practical work are too demanding for students | Negative | $N_3$ |
| Mathematics should be avoided in chemistry practical work | Negative | $N_4$ |
| Practical work in chemistry helps students acquire skills of doing experiments | Positive | $P_1$ |
| During practical work in chemistry students should verify whether what they do in chemistry theory is true | Positive | $P_2$ |
| The students should help the teacher when s/he is demonstrating an experiment | Positive | $P_3$ |
| Practical work makes it possible for students to learn chemistry using most of their senses | Positive | $P_4$ |

| | | |
|---|---|---|
| There should be continuous assessment in chemistry practical work which should be included in the final examination | Positive | $P_5$ |
| Skills gained when doing practical work are more important than just getting the right answers | Positive | $P_6$ |

| Code | SA | A | NS | D | SD | Total |
|---|---|---|---|---|---|---|
| $N_1$ | 0 | 0 | 0 | 1 | 3 | 4 |
| $N_2$ | 0 | 0 | 0 | 1 | 3 | 4 |
| $N_3$ | 0 | 1 | 1 | 1 | 1 | 4 |
| $N_4$ | 1 | 0 | 0 | 1 | 2 | 4 |
| $P_1$ | 3 | 1 | 0 | 0 | 0 | 4 |
| $P_2$ | 2 | 2 | 0 | 2 | 0 | 4 |
| $P_3$ | 2 | 1 | 1 | 0 | 0 | 4 |
| $P_4$ | 3 | 1 | 0 | 0 | 0 | 4 |
| $P_5$ | 1 | 1 | 1 | 1 | 0 | 4 |
| $P_6$ | 1 | 1 | 1 | 0 | 1 | 4 |

Table 4.12 shows the frequency counts of the responses from the CTQ on the Likert scale.

# CHAPTER FIVE

# SUMMARY, CONCLUSION AND RECOMMENDATIONS

## 5.1 Conclusions

The main resources investigated in this study were the science laboratory and laboratory technicians.

a) Laboratories

From the results of this study, senior high school in the study sampled in the four selected schools in their respective regions[ West Africa SHS- Greater Accra region, Assin North SHS – Central region, Somenya SHS – Eastern region and Aveyime SHS – Volta region] were found to have laboratories that were well equipped with apparatus and chemicals to enable practical work in chemistry to be conducted. The implication of this finding is that students can be given opportunities to engage in a variety of activities that may enhance the development of a variety of scientific skills and hence promote understanding of concepts in chemistry. It was however noted that functional fume chambers and first aid boxes were absent in laboratories in most senior high schools. These two facilities help in ensuring the safety of laboratory users (students, teachers and laboratory technicians). This finding would most likely affect the activities in chemistry practical work that teachers arranged for students. It would also compromise on the quality of first aid that anyone would wish to offer to a victim of a laboratory accident.

**b) Laboratory Technicians**

The results of this study showed that most secondary schools in the study sample had only one laboratory technician to manage preparations for practical work in all the three science laboratories. This may be considered an overload on the part of laboratory technicians. An overloaded laboratory technician may not be effective in terms of managing laboratory activities thereby calling on the chemistry teacher and other science teachers in general to step in to assist. As a result, the teachers' ability to plan for practical experiences and chemistry lessons may be affected negatively.

## 5.2 Skills emphasized during Practical Work in Chemistry

The results of this study revealed that teachers of chemistry were in a good position to arrange for experiences in practical work in chemistry in which students could develop a variety of scientific skills. The teachers were well qualified, had long experience of teaching chemistry and had positive attitudes towards practical work in chemistry. However, only certain skills were emphasised by the chemistry teachers both in teaching and in assessment. The main skills emphasised were: observation, manipulation of apparatus and materials and recording data. Some of the key scientific skills not seriously emphasised by the teachers included: aspects of experimental design and hypothesis formulation. As long as such skills continued to lack in practical work in chemistry lessons, students graduating from the secondary schools would be those not likely to take part in the process of generating scientific knowledge but only consumers of such knowledge.

## 5.3 Recommendations

Teachers of chemistry were found to be qualified with enough long teaching experiences and their teaching load was manageable. As such it is recommended that they need to take advantage of the positive attitudes students have towards practical work to involve them in as many activities as possible in order to enhance the acquisition of the various scientific skills.

The WAEC on the other hand needed to diversify the skills students were assessed in chemistry practical work in order to put the teachers on the alert all the time. They could for example include simple aspects of experimental design in the assessment.

Secondly, board of governance and PTA committees as school mangers should be charged with the responsibility of provision of teaching/learning facilities. This study revealed that schools in the study sample were in short of functional fume chambers and first aid boxes. In view of this finding it is recommended that the school managers look into ways and means of maintaining fume chambers and first aid boxes in laboratories. To facilitate experimentation, schools that had more than one laboratory need to employ one technician per available laboratory to reduce the load on the science teachers so that they could concentrate on the actual lesson planning and teaching.

## REFFERENCES

*APU (1984). Science in Schools: Age 15 no 2*. DES, London

Ary, D., Jacobs, L. and Razeriah, A. (1972). *Introduction to Research in Education.* Holt, Reinhart and Winston, New York.

Ausubel, D. P. (1968). *Educational Psychology: A Cognitive View.* New York, Holt, Rinehart and Winston

Baird, J. R. (1986). *'Improving learning through enhanced meta-cognition: a classroom study'* European Journal of Science education, 8, 263-82.

Baird, J. R. (1990). *Metacognition, purposeful enquiry and conceptual change*. In E. Hegarty-Hazel (ed.), The student laboratory and the science curriculum (pp. 183–200). Routledge, London.

Baird, J. R. and Mitchell, I. J. (eds) (1986). *Improving the quality of teaching and learning:* an Australian Case Study-The Peel Project. Faculty of Education, Monash University, Melbourne.

Baird, J. R. and White, R. T. (1982a). *'A case study of learning styles in Biology',* European Journal of Science Education, 4, 325-37

Baird, J. R. and White, R. T. (1982b). *'Promoting self-control of learning',* Instructional Science, 11, 227-47

Barron, B. J. S., Schvartz, D. L., Vye, N. J., Moore, A., Zech, L. and Bransford, D. J. (1998*). Doing with understanding: Lessons from research on problem and project-based learning.* The Journal of the Learning Sciences, 7, 271–311.

Bell, J. (1997). *Sex differences in performance in double Award Science GCSE*. A paper presented at the British Educational Research Association Annual Conference, 11-14 September 1997, University of York.

Berry, A. Mulhall, P., Loughran, J. J. and Gunstone, R. F. (1999a). *Helping students learn from laboratory work.* Australian Science Teachers' Journal, 45(1), 27- 31.

Berry, A. Mulhall, P., Loughran, J. J. and Gunstone, R. F. (1999b). *Exploring students' approaches to laboratory work.* (Manuscript under review).

Bruner, J. S. (1966). *'Some elements of discovery'*. In Shulman, L. S. and Keisler, E. R. (eds), Learning by Discovery: A critical Appraisal. Rand McNally, Chicago.

Cohen, L. and Manion, L. (1994). *Research Methods in Education,* 4th Ed. Routledge, London

Cuccio-Schirripa, S. and Steiner, H. E. (2000). *Enhancement and analysis of science question level for middle school students.* Journal of Research in science Teaching. 37, 210-224.
*From:http://www3.interscience.wiley.com/cgi-Bin/abstract/69501665/ABSTRACT?CRETRY=1SRETRY=0*

Driver, R. (1983). *The Pupil as Scientist?* Open University Press, Milton Keynes.

Driver, R. (1995). *Constructivist approaches to science teaching.* In L. P. Steffe & J. Gale (Eds.), Constructivism in education (pp. 385–400). Hillsdale, NJ: Lawrence Erlbaum.

Driver, R. and Bell, B. (1985). *'Students' thinking and the learning of science: 'a constructivist view',* School Science Review, 67, 443-56

Egen, P. D., Kauchak, D. P. and Harder, R. J. (1979). *Strategies for teachers: Information Processing Models in the Classroom*. Prentice Hall, London.

Gagne, R. M. (1970). *The conditions of Learning, 2nd ed. Holt, Rinehart and Winston, New York.*

Gastel, B. (1991). *Teaching Science: A guide for college and professional school instructors.* The Oryx Press, Canada.

Giddings, J. Hofstein, A and Lunetta, V. (1991). *Assessment and Evaluation in the Science Laboratory.* In Woolnough, B (ed.) 'Practical Science. Cambridge University Press, Cambridge.

Gorard, S., Rees, G. and Salisbury, J. (2001). *Investigating the Patterns of Differential Attainment of Boys and Girls at School.* British Educational Research Journal, 27(2),125-39.

Gunstone, R. F. and Champagne, A. B. (1990). *'Promoting conceptual change in the laboratory'* in Hegarty-Hazel, E. (ed.), The Science Curriculum and the Student Laboratory. Croom Helm, London.

Henderson, D. Fisher, D. and Fraser, B. (2000). *Interpersonal Behaviour, Laboratory Learning Environments, and Student Outcomes in Biology Classes.* Research Journal in Science Teaching, 37, 26-43.

Henry, N. W. (1975). *'Objectives for Laboratory work'.* In Gardner, P. L. (ed), The structure of science education. Vic., Longman, Hawthorne.

Hodson, D (1990). *A Critical look: at practical in school science*. School Science Review, 71 (256) 33-40.

Hudson, T (1994). *Developing pupils' skills.* In R. Levinson (ed.) Teaching science. Routledge, London.

Hofstein, A. and Lunetta, V. N. (1982). *'The role of the laboratory in science teaching: the neglected aspects of research',* Review of Educational Research, 52, 210-17.

Iraki, N. W. (1994). *Students and teachers' expectations of practical work in physics.* Unpublished M Ed Thesis. Kenyatta University, Nairobi.

Johnstone, A. H. (1997). *Chemistry teaching, science or alchemy?* Journal of Chemical Education. 74(3): 262-81.

Kelly, A. (1978). *Girls and Science: An International Study of Sex Differences in School Science Performance.* Almqvist and Wiskell, Stockholm

Kelly, A. (1981). *'Sex differences in science performance'* In A. Kelly (ed), The Missing Half. Manchester University Press, Manchester.

Khor, S. Y. (1987). *A study of Academic Self-Concept and its Relation to Academic Performance in two Samples of Singaporean Pupils.* Institute of Education, Singapore.

Koul, L. (1984). *Methodology of Educational Research*. Vikas Publishing House Pvt Ltd, New Delhi.

Laforgia, J. (1988). The *Affection Domain Related to Science Education and its Evaluation.* Science Education, 72, 407-421.

Lawson, A. E, Abraham, M. R. and Renner, J. W. (1989). *A Theory of Instruction*, NARST Monograph No 1

Lazarowitz R. & Tamir, P. (1994). *Research on using laboratory instruction in science.*

In D. L. Gabel (Ed.), Handbook of research on science teaching (pp. 94–127). Macmillan. New York

Levinson, R. (ed.) (1994). *Teaching Science. Routledge,* London

Majani, T. A. (1989). *Factors that contribute to poor performance in O-level KCE chemistry examination.* Unpublished PGDE Thesis, Kenyatta University, Nairobi.

Millar, R (2004). *The role of practical work in teaching and learning of science.* Unpublished paper prepared for the meeting: High School Science Laboratories: The role and vision. National Academy of Sciences, Washington, DC From: *http://www7.nationalacademies.org/bose/Millar/draftpaper/Jun* 04

MoE (2010). *Minister of Education teaching syllabus for chemistry (senior high school 1-3)*

Murphy, P. and Got, R. (1984*). Science Assessment Framework Age 13 and 15,* Science Report for Teachers: 2. ASE

Mugenda, O. M. and Mugenda, A. G. (1999*). Research methods: Quantitative and Qualitative Approaches.* Acts Press, Nairobi.

Musoko, J. N. (1983). *The role of the laboratory in teaching 'O' level physics.* Unpublished, PGDE Thesis, Kenyatta University, Nairobi.

Orwa, W. O. and Underwood, M (1986). *Science Education.* Kenyatta University, Nairobi

Osborne, R. and Freyberg, P. (eds.) (1985). *Learning in science.* : The implications of children's science. Heinemann, Auckland.

Paris, S. G., Cross, D. R. and Lipson, M. Y. (1984). *'Informed Strategies for Learning: a program to improve children's reading awareness and comprehension',* Journal of Educational Psychology, 76, 1239-52.

Penick, J. E., Crow, L. W. and Bonnsteter, R. J. (1996). *Questions are answers.* The Science Teacher, 63, 26-29.

Schibeci, R. A. (1984). '*Attitudes to Science: an update'*, Studies in Science Education, 11, 26-59

Schibeci, R. A. and Riley, J. P. II (1986*). Influence of Students' Background and Perceptions on Science Attitudes and Performance.* Journal of Research in Science Teaching, 23, 177-87

Schwab, J. J. (1960). *'Enquiry - The science teacher and educator',* The science teacher, 27, 6-11

Schwab, J. J. (1962). *'The teaching of science as enquiry'* In Schwab, J. J. and Brandwein, P. F. (eds.), The teaching of Science. MA, Harvard University Press, Cambridge.

Shayer, M. and Adey, P (1981). *Towards a science of science teaching: Cognitive Development and Curriculum Demand.* Heinemann Educational Books, London.

Smith, F. (1975). *Comprehension and Learning*. Holt, Rinehart and Winston, New York.

Tamir, P and Lunetta, V, N. (1981). *'Inquiry related tasks in high school science laboratory handbooks'*, Science education, 65, 477-84.

Tasker, R. (1981). *'Children's views and classroom experiences'*, Australian Science Teachers' Journal, 27, 33-7.

Tobin, K. G. and Gallagher, J. J. (1987). *What happens in high school scienceclassrooms?* Journal of Curriculum studies, 19, 549-560

TSC (2005). ). *'Improving learning through enhanced meta-cognition: a classroom study'* European Journal of Science education, 8, 263-82.

Twoli, N. W. (2006). *Teaching secondary school chemistry; A textbook for teachers in developing Countries.* Nehema publishers, Nairobi

UNESCO, (1973). *New UNESCO source book for science teaching.* UNESCO, Paris.

WAEC (2010*). West Africa Examination Council. Syllabus for chemistry.*

Weld, J. (ed) (2004). *The game of science education.* Pearson Education, Inc. USA.

Wellington, J. J. (1981). '*What's supposed to happen, sir?'- Some problems with discovery learning.* School Science Review, 63, (222), 167-73

White, R. T. (1982). *'Memory for personal events'*, Human Learning, 1, 171-83

White, R. T. (1989). *'Recall of autobiographical events',* Applied Cognitive Psychology, 3, 127-35.

Wilson, E. (1999). *Teaching Chemistry to KS4.* Hodder and Stoughton, London.

Winberg, M. (2006). Research Thesis; *on Simulation in University Chemistry Education: Cognitive and Affective Aspects.* Umea University, Umea.
From: *http://www.diva-portal.org/umu/thesis/searchresult.xsq.*

Woolnough, B. and Allsop, T. (1985). *Practical Work in Science*. Cambridge University Press, Cambridge.

Woolnough, B (ed.) (1991*). Practical Science.* Open University Press, Buckingham.

Yung, B. H. (2001). *Three views of fairness in a school-based assessment scheme of practical work in biology.* International Journal of Science Education, 23, 985–1005.

# APPENDICES

Appendix 1: Chemistry Teachers' Questionnaire (CTQ) (To be completed by chemistry teachers in the school)

The purpose of this questionnaire is to solicit information concerning practical work in chemistry from practising senior high school chemistry teachers in the region.

You are kindly requested to answer the questions below honestly. Your kind and honest cooperation will go a long way in assisting to achieve the goal of this study, which is to enhance the participation of both the teachers and the students in practical work in chemistry for effective teaching and learning.

This questionnaire is made up of three sections; A, B and C. Answer questions in all the sections. All you are required to give are answers to questions and personal opinions. The information obtained will be treated with strict confidence.

You need not write your name anywhere in this questionnaire. Tick (√) the relevant/appropriate answers or fill in the blank spaces.

No answer is necessarily correct or wrong. Feel free to give answers you consider appropriate.

**Section A: General information about the teacher and school**

1.Type of school Boys only[ ] Girls only [ ] Mixed [ ]

2.Indicate your gender Male [ ] Female [ ]

3. Up to what level did you learn academic chemistry?

'O' Level [ ], 'A'Level [ ], SSCE/WASSCE [ ], University [ ]

4. What is your professional qualification?

B.Ed. (Sc) [ ], B.Sc. with PGDE [ ], B.Sc. only [ ],
Diploma in Sc. Ed [ ], Others [ ]
If your answer is others please specify.

………………………………………………………………………………………………
………………………………………………………………………………………………
………………………………………………………………………………………………
…………………………………………………………..

5. How long have you been teaching chemistry in years?
   Less than 2 [ ], 2-5 [ ], 6-10 [ ], 11-15 [ ], More than 15[ ]
6. How many chemistry periods do you have per week?
   6 [ ], 12[ ], 18 [ ], 24[ ] More than 24[ ]
7. What is your total teaching load per week? [ ] periods.

8. What is your second teaching subject?

Maths ⊏⊐, Physics⊏⊐, Biology⊏⊐, Integrated science, Others⊏⊐

If your answer is others please specify……………………………………………

**Section B: Facilities/resources, skills emphasized and general organization of practical work in chemistry**

9. How many laboratories does your school have?

(a) *One lab for each of the following science subjects (Bio, Phy, Chem, Int. sci., Agric sci. ⊏⊐)*

(b) *Two labs for all the science subjects ⊏⊐,*

(c) *One lab for all the science subjects ⊏⊐,*

(d) *Others⊏⊐*

If your answer is others please specify ……………………………………………

10. (i) How many laboratory technician(s)/assistant(s) does your school have?

(a) One for each of the laboratories ⊏⊐

(b) Two for all the laboratories ⊏⊐

(c) One for all the laboratories ⊏⊐

(d) Others ⊏⊐

If your answer is others please specify

………………………………………………………………………………………………
………………………………………………………………………………………………
…………………………………………………………………………

(ii) Indicate whether the laboratory technician(s)/assistant(s) in your school have been trained or not by filling the table below appropriately

| Number of lab technicians/assistants | Number trained | Number not trained |
|---|---|---|
| | | |

11. a) In your laboratory indicate availability of the following by ticking (√) in the appropriate column

| | | **Availability** | |
|---|---|---|---|
| | | **Available** | **Not available** |
| i) | Work Benches | | |
| ii) | Stools | | |
| iii) | Apparatus e.g. burettes, pipettes, beakers | | |
| iv) | Running water | | |
| v) | Functional fume cupboard | | |
| vi) | Chemicals' store | | |

| | | | |
|---|---|---|---|
| vii) | First aid box | | |
| viii) | Chemicals stock | | |

(b) Do you have sufficient chemicals for;
  (i) the whole year? [ ]
  (ii) only part of the year? [ ]

12. How many periods per week per class do you conduct chemistry practical? Tick (√) appropriately

| | 2 periods | 1 period | none |
|---|---|---|---|
| SHS 1 | | | |
| SHS 2 | | | |
| SHS 3 | | | |

13. a) How do you organise chemistry practical for your students?
  1. Individually [ ]
  2. Groups [ ]

(b) If in groups what is the number per group? [ ]

14. To what extend would you say the following aims are achieved in your chemistry practical work with your students? Indicate your responses by ticking to the following specifications.

| **Rank** | **Response** |
|---|---|
| 1 | Not at all |
| 2 | To a small extent |
| 3 | To a satisfactory extent |
| 4 | To a large extent |
| 5 | To a very large extent |

The following are some of my aims for chemistry practical work.

| | Aims | Rank | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| i) | To teach basic practical skills | | | | | |
| ii) | To familiarise students with standard apparatus and measuring techniques | | | | | |
| iii) | To train students in making relevant observations | | | | | |
| iv) | To train students in recording their observations accurately | | | | | |
| v) | To train students in making logical deductions based on relevant observations and interpretations of experimental data | | | | | |
| vi) | To use experimental data to find solutions to questions | | | | | |
| vii) | To train students in experimental write-ups | | | | | |
| viii) | To train students in recognising simple experimental design | | | | | |
| ix) | To arouse and maintain students' interest in the subject | | | | | |
| xi) | To show the use of practical work as a process of verification | | | | | |
| xii) | To help bridge theory and practice | | | | | |
| xiv) | To train students in how to ask and answer questions concerning scientific phenomena | | | | | |

15. (a) Do you carry out chemistry practical work with our students?

Yes ⊏⊐, No ⊏⊐,

(b) If yes, at what level do you start?

SHS 1 ⊏⊐, SHS 2 ⊏⊐, SHS 3 ⊏⊐

16. (a) Do marks obtained by students in practical work in chemistry form part of their continuous assessment? Yes ⊏⊐, No ⊏⊐,

(b) If yes, at what level do you start including the marks to form part of the continuous assessment?

SHS 1 ⊏⊐, SHS 2⊏⊐, SHS 3 ⊏⊐,

(c)If no why?

………………………………………………………………………………
………………………………………………………………………………
………………………………………………………………………………
…………………………………………………

**Section C: Personal opinion about practical work in chemistry**

Below are statements regarding practical work in chemistry with letters SA (Strongly Agree), A (Agree), NS (Not Sure), D (Disagree) and SD (Strongly Disagree) against each statement. The researcher is interested in knowing how you feel about each statement. Respond by ticking (√) in the column with the most appropriate letter(s) depending on how you feel about each statement.
There are no right or wrong answers. Just choose freely and honestly

| | **Statements** | **SA** | **A** | **NS** | **D** | **SD** |
|---|---|---|---|---|---|---|
| 18 | Practical work in chemistry helps to students acquire skills in doing experiments | | | | | |
| 19 | The chemistry teacher should carry out activities in chemistry practical work as the students sit back and watch | | | | | |
| 20 | During practical work in chemistry students should verify whether what they learn in theory is true | | | | | |
| 21 | The students should help the teacher when s/he is demonstrating an experiment | | | | | |
| 22 | Practical work makes it possible for students to understand chemistry since they use most of their senses | | | | | |
| 23 | Practical work makes the learning of chemistry very difficult | | | | | |
| 24 | Examinations in chemistry practical work are too demanding for the students | | | | | |
| 25 | There should be continuous assessment in chemistry practical work which should be included in end of term examinations | | | | | |
| 26 | Mathematics should be avoided in chemistry practical work | | | | | |
| 27 | Skills gained when doing practical work are more important than just getting the right answers | | | | | |

28. Any other issues, ideas or suggestions not included in this questionnaire, that you think could contribute towards better practice and performance in practical chemistry practical.

…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………

**Thank you for accepting to participate in this study**

Appendix 2: Chemistry Students Questionnaire (CSQ) (To be completed by Form three chemistry students in the school)

The purpose of this questionnaire is to solicit information concerning practical work in chemistry for **Form Three** chemistry students in secondary schools in the school.

You are kindly requested to answer the questions below honestly. Your kind and honest cooperation will go a long way in assisting to achieve the goal of this study, which is to enhance the participation of students in practical work in chemistry for their own benefit.

This questionnaire consists of two sections, A and B. Answer all the questions in both sections.

Section A: Student's background information

1. Type of school Boys only [ ] Girls only [ ] Mixed [ ]
2. Indicate your gender Male [ ] Female [ ]

**Section B: Personal opinion about practical work in chemistry**

Below are statements regarding practical work in chemistry with letters SA (Strongly Agree), A (Agree), NS (Not Sure), D (Disagree) and SD (Strongly Disagree) against each statement. The researcher is interested in knowing how you feel about each statement. Respond by ticking (√) in the column with the most appropriate letter(s) depending on how you feel about each statement.

There are no right or wrong answers. Just give your views freely and honestly

| | Statements | SA | A | NS | D | SD |
|---|---|---|---|---|---|---|
| 3 | Practical work in chemistry helps me acquire skills in doing experiments | | | | | |
| 4 | The chemistry teacher should carry out most of the activities during practical work in chemistry while the students sit back and watch | | | | | |
| 5 | The chemistry teacher helps us to make accurate observations during practical work in chemistry | | | | | |
| 6 | The students should help the teacher when s/he is demonstrating an experiment | | | | | |
| 7 | Practical work makes the learning of chemistry very difficult | | | | | |
| 8 | Practical work in chemistry makes me understand chemistry better | | | | | |
| 9 | The chemistry teacher explains the theory behind the experiments we carry out. | | | | | |
| 10 | Mathematics should be avoided in chemistry practical work | | | | | |
| 11 | Chemistry practicals are enjoyable | | | | | |
| 12 | Laboratory chemicals make me fear chemistry | | | | | |
| 13 | We cannot make new discoveries in science(chemistry) without practical work | | | | | |
| 14 | Practical work in chemistry gives me another chance to understand things that I do not understand during theory lessons | | | | | |
| 15 | Skills gained during practical work are very important than just getting the right answers | | | | | |
| 16 | The chemistry teacher should help students during practical work only when they get stuck | | | | | |

**Thank you for accepting to participate in this study**

Appendix 3: Lesson Observation Schedule (LOS) (To be completed by the researcher)

**Section A: Background**

1. Name of school……………………………………………….
2. Teachers' gender……………………………………………..
3. Type of school………………………………………………..
4. Lesson duration…………………..…………………………..
5. Number of students in class…………………………………….
6. Size of groups…………………………………………………

**Section B: Organization and Procedures**

a) Lesson type

Teacher Demonstration □, Class experiment □, Others□ If your answer is others please specify

……………………………………………………………………………….……….

How were the instructions given?

Orally □, Student worksheet □, Chalkboard □ b) Apparatus and material distribution

Apparatus arranged in groups beforehand □

Students pick apparatus and requirements before starting □

**Section C: Interactions**

| | |
|---|---|
| A: Teacher to Student | All activities that are initiated by the teacher. They include responses to students answers |
| B: Student to Teacher | All activities that are initiated by the student. They include asking and answering questions |
| C: Student to Materials/ Apparatus | All activities in which students will be working with apparatus/materials. They include working from manuals or laboratory guides, and recording of observations. |
| D: Student to Student | All activities where students are discussing either in groups or as a class. They include consultations among the students |
| E: Silence or Confusion | when no interaction is observable |

**Likely behaviour under the categories**

| Category | Behaviour/skill |
|---|---|
| A | 1. Teacher introduces the lesson and states purpose of practical work |
| | 2. Teacher demonstration |
| | 3. Teacher asks students to design experiment |
| | 4. Teacher assists students in working with apparatus/materials |
| | 5. Teacher asks questions, answers students questions and acknowledges students responses |
| B | 1. Students assist teacher during demonstration |
| | 2. Students ask and answer questions |
| | 3. Students give experimental reports |
| C | 1. Students design investigations/experiments |
| | 2. Students follow the step by step instructions in the lab guide/worksheet/chalkboard to carry out practical work |
| | 3. Students make and record observations |
| D | 1. Students analyse data, discuss any trends with each other and draw conclusions |
| E | 1. Noise/ confusion |

**Note:** Behaviour/skill number will be recorded after every 1 min. alongside the category. For example $A_1$ refers to behaviour number 1 under category A

**Section D: Evaluation**

How well did the teacher accomplish the following tasks?

| | | Very well | Satisfactory | Not at all |
|---|---|---|---|---|
| i) | Give instructions | | | |
| ii) | Handle safety aspects | | | |
| iii) | Use the available resources | | | |
| iv) | Involve students in discussions | | | |
| v) | Answer students questions | | | |
| vi) | Motivate students | | | |
| vii) | Ask questions | | | |
| viii) | Achieve his/her objectives | | | |

Appendix 4: Document Analysis Guide (DAG) (To be used by the researcher)

CTQs from each school in study sample will be analysed with regard to skills emphasised by teachers in teaching and assessment of practical work in chemistry. Also WAEC syllabus and past examination papers for chemistry practical work for the years 2011, 2012 and 2013 will be analysed for skills assessed by WAEC. The results of analysis will be recorded in the table below and examined for any trends.

| **Skills emphasised during teaching** | **Skills assessed by teachers** | **Skills assessed by WAEC** |
|---|---|---|
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