TEACHERS' COMPETENCIES IN THE DESIGN AND DELIVERY OF CHEMISTRY PRACTICAL WORK

BY

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A dissertation submitted to the University of Zambia in partial fulfilment of the requirements of the degree of Master of Education in Science Education.

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DECLARATION

I, Chama Sarah, do hereby declare that this dissertation represents my own work and that it has not previously been submitted for a degree or other qualification at the University of Zambia or any other University.

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APPROVAL

This dissertation of……………………………………….is approved as fulfilling the partial requirements for the award of the Degree of Master of Education in Science Education by the University of Zambia.

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ABSTRACT

The aim of the study was to investigate chemistry teacher's competencies in the design and delivery of chemistry practical work in selected schools of Kitwe District. The objectives of the study were to: determine the nature of chemistry practical activities designed and delivered by teachers of chemistry, establish the range of science process skills developed through the practical activities designed by teachers of chemistry and describe the level of creativity in practical activities designed by the teachers of chemistry. The study used a qualitative approach and a case study design. The target population was chemistry teachers teaching the two chemistry syllabi; pure Chemistry (5070) and Science (5124) in selected schools of Kitwe district. The sample comprised of six chemistry teachers and 24 pupils drawn from three secondary schools. The study involved the use of: observation schedule, semi-structured interview schedule, focus group discussion guide and document analysis schedule to collect data. The findings showed that most of the practical activities designed by teachers were characterised by learners following laid down procedures. It was also noted that the focus of most of these practical activities was to expose learners to pieces of apparatus, verify and confirm what was discussed during theory lessons. The range of science process skills developed from the nature of chemistry practical activities designed and delivered by chemistry teachers were; observation, classification, communication, measuring, experimenting, interpreting data and using numbers. However, these process skills were not effectively developed to the extent that could lead learners to construct their own understanding. There was no variety in the practical activities given to the learners, pointing to lack of creativity and innovation in the practical activities designed by chemistry teachers. There is need for science teacher educators to strengthen their education programs in terms of student exposure to practical activities especially investigative ones. Science standard officers should organise workshops and continuous professional development for chemistry teachers to train them on how to design practical activities. Chemistry teachers should form communities of practice so as to share ideas on practical activity design and material improvisation.

Keywords: *Teachers' competency, Science process skills, Practical work, Designing*

DEDICATION

This work is dedicated to my late parents Chama R. K and A. M Chama for inculcating in me the importance of education and hard work at a tender age. I will forever be grateful.

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ABBREVIATIONS

CDC:	Curriculum Development Centre
CPD:	Continuous Professional Development
ECZ:	Examination Council of Zambia
NRC:	National Research Council
SCORE:	Science Community Representing Education
SPS:	Science Process Skills

CHAPTER ONE: INTRODUCTION

1.1 Introduction

This chapter presents the introduction of the study by providing the background information, statement of the problem, purpose, objectives as well as questions. Additionally, the significance, scope and limitations of the study are presented. Thereafter theoretical framework, conceptual framework and operation definitions are outlined.

1.2 Background

Millar (2010) describes science as a product (body of knowledge), a process (a way of conducting enquiry) and as an enterprise (an institutionalised pursuit of knowledge of the material world). The view of science as a process calls for the development and delivery of science practical activities. In Zambia science is made up of Physics, Chemistry, Biology, Agricultural Science and Integrated Science as outlined in the Zambia National Education Curriculum Framework of 2013. This is at secondary and junior secondary levels respectively.

The study was interested in chemistry practical activities and the range of process skills that can be developed. Chemistry is a science that describes matter, its properties, the changes it undergoes and the energy changes that accompany those processes. The teaching of Chemistry in secondary schools is guided by two syllabi; 5070 pure chemistry and 5124 a combination of Chemistry and Physics. The main difference in these two syllabi is that 5070 is only composed of Chemistry, while 5124 has Chemistry and Physics components. These components are taught separately and only combined during final examination (CDC, 2013).

Statistics from the examination council of Zambia (ECZ) covering the years 2006 to 2010 and 2013 to 2016 show that learner's performance in Chemistry (5070) and Science (5124) has been consistently poor as shown in Table 1.1. Appendix F highlights the performance of learners in pure Chemistry 5070 and Science 5124 of 10 secondary schools sampled from the 10 provinces by the Examination Council of Zambia covering the years 2006 to 2010. The 2014 examination performance report also reveals that learners' have continued to perform poorly in science country wide. The report further points out that the average performance fell below the pass mark of 40% (ECZ, 2014).

Table 1.1: Average performance of learners in science (5124) from 2013 to 2016

YEAR	2013	2014	2015	2016
PASS % PERFORMANCE	33.30	17.76	17.66	32.83
AV. PERFORMANCE	25.39			

The chief examiners reports for 2015 and 2016 specifically indicate that the general performance in practical work was poor. The reports highlight that learners had challenges: making observations and undertaking a critical analysis of their observations, drawing conclusions from their observations and applying their theoretical knowledge to explain observations and results from experiments. Further the reports point out that learners exhibited poor psychomotor skills in practical activities and poor layout of results such as tabulating results.

This poor performance may among other factors be attributed to teachers' competencies in designing and guiding learners in performing the science practical activities. Skills and competency of teachers in handling the instructional process with the help of pedagogy, teaching and learning aids is of great importance in the learning process (Katane and Selvi, 2006).

Jimmi (2004:313) describes teachers competency as a "set of knowledge, skills and proficiency in creating meaningful experiences when organising an activity". This suggests that teachers' ability to design and deliver practical work is key in enhancing conceptual understanding. But in the light of what Examination Council of Zambia says about high failure rate this may not be happening in the majority of the Zambian Schools.

1.3 Statement of the Problem

A number of studies have been done on learners poor performance that highlight class size, inadequate teaching and learning materials, lack of conventional laboratories and lack of support for teachers as among other factors contributing to learners' low performance in chemistry (Nkoya, 2008; Chocha et al, 2014). Conceptual understanding of chemistry is influenced by the opportunities given to learners to experience scientific phenomena through hands-on activities. Hence forth, learners' poor performance may be attributed to the skill and tact of Chemistry teachers in creating and implementing meaningful practical activities. It is against this background that the study was done in order to investigate Chemistry teachers' competencies in the design and delivery of practical work.

1.4 Purpose of the study

The purpose of the study was to investigate chemistry teachers' competencies in the design and delivery of practical lessons in selected secondary schools of Kitwe district of Copperbelt province in Zambia.

1.5 Research objectives

The study was guided by the following objectives:

(a) To determine the nature of Chemistry Practical Activities designed and delivered by Chemistry teachers.

(b) To establish the range of Science Process Skills developed through chemistry teacher designed practical activities.

(c) To describe the level of creativity in teacher designed chemistry Practical Activities.

1.6 Research questions

The study sought to answer the following questions:

(a) What is the nature of Chemistry Practical Activities designed and delivered by chemistry teachers?

(b) What Science Process Skills are developed through Chemistry Teacher designed Practical Activities?

(c) What is the level of creativity in teacher designed Chemistry Practical Activities?

1.7 Significance of the study

The study might help science teacher educators to strengthen and modify their teacher education programs in terms of student exposure to practical activities. Chemistry teachers may also benefit from the study by establishing whether the practical work they do in their classrooms is adequate to enhance learners understanding of chemistry concepts and develop science process skills. Additionally, the findings of this study might also provide information about the actual chemistry teaching and learning in secondary schools that might be of help to science curriculum planners, standard officers, other researchers and government as a whole.

1.8 Scope /delimitations of the study

The study was limited to Kitwe District of Copperbelt Province. It was conducted in three selected secondary schools in the district and it focused on Chemistry teachers' competencies in designing and delivering of practical work. It involved 6 grade 11 chemistry teachers and their classes.

1.9 Limitations of the study

The study was aimed at getting thick descriptions and deeper understanding of teacher's practical work design and delivery in chemistry. Thus, a small sample was used which may not be representative of all the teachers in the district. The sample also comprised of grade 11 pupils from classes doing pure chemistry (5070) syllabus and those doing science (5124) syllabus. The Pupils from pure chemistry classes may have had more exposure to practical activities compared to their counterparts hence compromising the representativeness and generalizability to typical classes.

1.10 Theoretical Framework

This study was informed by the core constructs of science as inquiry and the social constructivism theory. Scientific inquiry refers to methods and activities that lead to the development of scientific knowledge (Schwartz, Lederman and Crawford, 2004). National Research Council (2000) describes scientific inquiry from the classroom context as a set of abilities and understandings that include asking scientifically oriented questions, giving priorities to evidence in responding to questions, formulating explanations and connecting to scientific knowledge and justifying explanations

The social constructivism theory of learning stipulates that learners are active in the construction of their knowledge. Vygotsky (1978) amplifies this point when he states that social interactions are important in the construction of this knowledge. The theory focuses on a number of teaching/learning methods such as inquiry, problem solving, discovery and project work (Schunk, 2012). All these methods place emphasis on the active participation of the learner. This theory underpins the use of hands-on activities such as practical work in the teaching and learning process of science. Practical work involves learners to work either individually or in small groups in manipulating and/or observing real objects and materials (Abrahams and Reiss, 2012). Teacher's competencies in the design and delivery of Chemistry Practical work is informed by science as inquiry and social constructivism through:

- Properly planned and properly executed Chemistry practical activities. This helps learners to construct their own knowledge through hands-on activities and interaction with peers.

- Giving priority to generation of evidence for scientifically oriented questions.
- Developing ability of learners to formulate scientifically sound explanations of their observations.

1.11 Conceptual Framework

Practical work is central to the teaching and learning of Chemistry. Millar (2010:2) refers to practical activity as “any teaching and learning activity which at some point involves the students in observing or manipulating the objects and materials they are studying”. However, teacher’s competence is key in realising this aim. Katane and Selvi (2006) add that a set of knowledge, skills and proficiency in providing a meaningful experience when organising a practical activity culminates into competency of a chemistry teacher. This study was adapted to examine chemistry teacher’s competencies in the design and delivery of practical work.

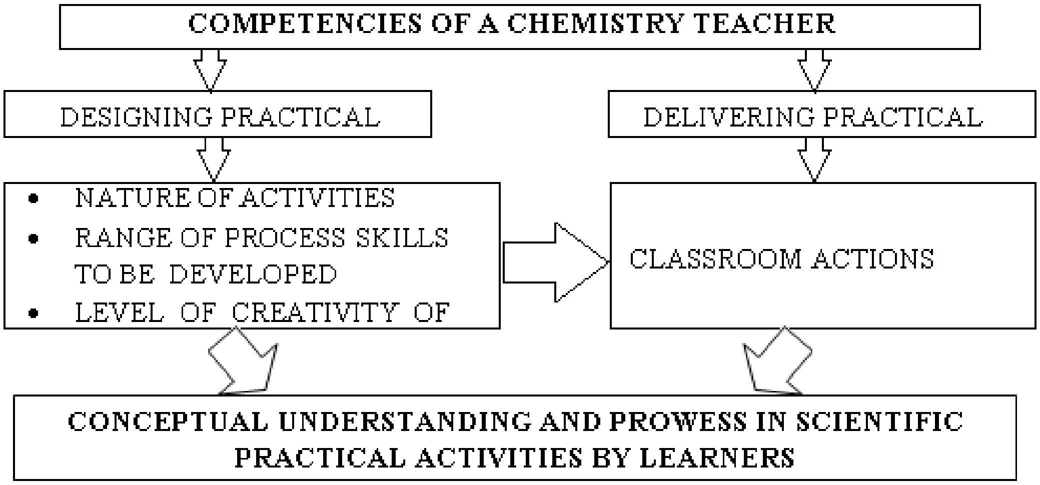

Figure 1: Interaction of ideas in the conceptual framework

1.12 Operation definitions

Teachers’ competency: A set of capabilities, skills, knowledge and proficiency in creating a learning experience for learners.

Science Process Skills: Procedures used by scientists to explore nature in order to come up with the content or scientific knowledge, so as to understand, explain, control and predict natural phenomena (Padilla,1990). In this study, science process skills referred to; observation, classification, communication, measuring, predicting, inferring, using numbers, identifying and controlling variables, interpreting data, formulating hypothesis, defining operationally and experimenting.

***Practical work*:** Any teaching and learning activity which involves at some point learners to use one or more of the science process skills as they interact with objects and materials under study.

Designing: Preparation of a practical activity or experiment for the Chemistry lesson so as to foster a range of science process skills.

1.13 Summary

The chapter looked at the introduction of the study by giving a description of the background information as well as the statement of the problem. The objectives, research questions and the significance of the study were also highlighted. The chapter further described the theoretical underpinnings and operational definitions of the study. In the next chapter I present the review of literature.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter reviews literature related to the study by looking at the role of practical work, science process skills development and teacher's competencies in designing and delivering science practical activities.

2.2 Role of Practical Work

Olufsen et al (2015:87) defines practical work as "any type of science teaching and learning activity in which students, working either individually or in small groups are involved in manipulating and/ or observing real objects and materials". Practical work has a key role in chemistry education from a lower level through to university. One of the features of chemistry as a science is the aspect of doing practical work. This is the case because the aim of chemistry is to increase our understanding of the composition, properties and changes of matter. Therefore, claims and explanations in chemistry should be substantiated by observations and interaction with materials. On the other hand Millar (2004) says that there are many benefits in engaging students in laboratory and other practical work. Among the many benefits in chemistry, practical work engages all the five sense of the learners as described by Petrusevski and Najdoski (2000:88) that;

1. The results of an experiment can be *seen.*
2. In most cases the results can be *heard* in form of pops or bangs (for example when testing for hydrogen gas).
3. The results could also be *smelled* (for example during the generation of ammonia).

4. The system (a beaker or flask where the reaction occurs) can be *touched*, for example in an exothermic reaction.
5. Under special circumstances it might be safe to *taste* the samples (for example, samples of glucose, fructose and sucrose).

Practical activities foster the students' interest in chemistry, support learning and contribute to a student-directed and inquiry-based learning environment (Hofstein and Lunetta, 2004). Therefore, teachers should provide opportunities for students to manipulate materials, make observations, collect data and be able to draw conclusions (Nghipandulwa, 2011). Machina (2012) also remarks that practical work provides concrete and authentic experiences that help students in comprehending the phenomena under study.

Science Community Representing Education (2008) outlines the following aims of doing practical work in schools: to encourage accurate observation, to make phenomena more real, to arouse and maintain interest, to promote logical and reasoning method of thought.

This implies that the role of practical work in science can best be achieved if all the above aims are embraced. In addition, Lunetta, Hofstein and Clough (2007:405) states that:

> When well-planned and effectively implemented, science education laboratory and simulation experiences situate learning in varying levels of inquiry requiring students to be both mentally and physically engaged in ways that are not possible in other science education experiences**.**

In a study conducted in Singapore, Zhai, Jocz and Tan (2014) focused on children's images of doing science in school. The findings indicate that students disclosed that they were acting like scientists when they were conducting hands-on experiments. The students further stated that it was more 'fun' when they made observations and predictions. There seems to be a consensus with the findings of another study carried out in Nigeria by Ogunmade (2005) aimed at the status and quality of science teaching and learning. The study used both quantitative and qualitative methods to collect data. The findings revealed that 51% of the respondents believed that practical work should be used to illustrate the concepts introduced during science lessons. Therefore, the role of practical activities in teaching and learning of chemistry and science in general cannot be over emphasised. This is because it provides opportunities for learners to develop science process skills and also enhances conceptual understanding.

Other scholars (Hodson, 1991; Osborne, 1993; Millar; 2010; Mwangi; 2016) have indicated that practical work as it is currently used in the teaching and learning of science is ineffective because learners are not encouraged to think critically in order to construct knowledge and understanding of science concepts. Hodson (1991:176) states that "as practised in many schools, it [practical work] is ill-conceived, confused and unproductive. For many children, what goes on in the laboratory contributes little to their learning of science …" This calls for the teacher to be skilful in designing practical activities that are meaningful for the learners. Osborne (1993) holds a similar view about the contribution of practical work to students' science learning. In the same line Millar (2010), indicates that students can only remember the observable aspects of practical tasks for months or years if the event is striking. Mwangi (2016:22) agrees with Millar's view by stating that "a practical task designed to enable the students to observe an object or phenomenon can easily become rather dull and uninspiring, unless it is striking and a memorable one". These concerns have serious implications on the nature of practical activities prepared by teachers for their chemistry lessons.

Hofstein and Lunetta (1982) observed that when suitable activities are used in laboratories there are chances that effective development and promotion of logic, inquiry and skills for problem-solving might occur. However, Sharpe (2012) contends that because students find doing practical work enjoyable does not mean that they will be thinking or learning about what they are doing but rather an opportunity to have the freedom of doing something different in learning. This implies that the idea of enhancing scientific knowledge through practical activities may not be easy to achieve. It may only be achieved if the teacher is creative enough in the design and delivery of practical activities.

Hodson (1992) points out that the lack of clear focus of the nature of what and how best practical work should be conducted in schools has contributed to difficulties in the learning of science. This is because a number of different approaches of practical work in secondary schools may influence the learning outcomes for learners in science. Millar (1998) also point out that even though teachers expect learners to learn scientific ideas from practical work, it is somewhat effective. Abrahams and Millar (2008) argues that learners only remember certain aspects of an experiment and the ideas behind the phenomena are rarely learned. Similarly, Hodson (1991) expresses a similar view that practical work is only effective as a teaching strategy for some teachers, some students and in some concepts. It is therefore, the role of science teachers to design practical activities that will help learners to gain an understanding of concepts by creating a link between ideas and phenomena.

2.3 Nature of Practical Work

There are various categorisation of practical work used in secondary schools and these may include; teacher demonstrations, class practicals and learners working on similar tasks individually or in small groups (Wellington, 2002). On the other hand Olufsen et al (2015) contend that practical work can be classified as; teacher demonstrations, cook book/recipe style experiments and open ended/ inquiry experiments. But what is frequently used in secondary schools is the recipe style. Though popular, this way of conducting practical work has been criticised by a number of scholars for various reasons (Gunstone and Champagne, 1990; Millar, 2004). These reasons have been highlighted by Olufsen et al:

> Cookbook experiments are ineffective way to learn science concepts and might give a wrong picture of how knowledge is developed in science, such experiments do not challenge the school students to think about the purpose of the experiment or the sequence of steps involved, Both the practical work and the following written report are often of a ritualised or formulaic nature. The school students focus on following the given step-by-step procedure and finishing the task… (2015:89)

The United Kingdom Office for Standards in Education as cited in Sharpe (2012) endeavours to explain that the nature of practical work in secondary schools is somehow dictated by the teacher with continued use of recipe style practical work or worksheets. This practice does not encourage learners to acquire inquiry skills and theoretical understanding of science. Ituma, Twoli and Khatete (2015: 110) narrates that "practices in practical work have been a cookbook trend where instructions are carried out like a recipe which reduces meaningful learning. The learners therefore, do not use scientific ideas to guide their actions during the practical activity and reflect on the data they collect". This clearly shows that the nature of practical activities done in secondary schools usually does not promote learners conceptual understanding of science concepts. Similarly Sharpe (2012) substantiates that a lot of time in practical work lessons is spent on setting up and organising equipment as well as drawing results tables. Therefore, the teacher's opportunity to discuss the scientific ideas in detail with the learners is restricted. Abraham and Millar (2009) emphasises the need for teachers to have a clear understanding of the reasons for doing practical work and the benefits it accords.

The role of the teacher in practical work is important in enhancing learners understanding of abstract, general and explanatory concepts. This is the case because teachers need to exploit opportunities to explain and discuss with the learners the aspects of the practical activity so the learners can construct knowledge and understanding (Chairam, Klahn and Coll, 2015). Additionally Millar (2004:9) stresses that "a typical practical activity should be followed by a period of discussions of the observations and measurements made, patterns in them (such as similarities, differences, correlations and trends) and how they might be interpreted".

In order to help learners develop scientific understanding the practical activity ought to be more demanding, rigorously designed and well prepared (Hodson, 1996).

2.4 Ideal Design and Delivery of Practical Activities

Millar (2004) gives an outline of the characteristics of an ideal design of practical activities. A practical activity should have clear learning objectives. The other aspect is that it should have a limited number of intended learning outcomes. This is important in keeping the learners focused on the skills and knowledge that the task designer wants them to acquire. If learners need a specific skill for the task then they should be exposed to opportunities to learn it before the practical activity so that it does not get in the way of the intended learning (Abrahams and Millar, 2009). An effective practical activity encourages the use of affordable and available equipment. Learners will be more minds-on and hands-on engaged if they feel they understand how the equipment they are using works.

Ituma, Twoli and Khatete (2015) did a study that was aimed at providing alternative approach on how to engage learners' minds more in practical activities. The study employed a design-based research approach. This methodology involves the designing /developing an intervention to solve a complex education problem. The findings revealed that the strategies used to teach practical work did not adequately focus learners' minds on the activity. They further indicated that the activities should be redesigned in order to support the implementation of investigative practical work in secondary school chemistry. Therefore, the focus of effective practical activities should be to enable learners to build a bridge between what they can see and handle and also the scientific ideas that account for their observations (Machina, 2012).

Additionally, an ideal practical activity is designed in a way that scaffolds learners thinking and channels their reasoning along productive lines (SCORE, 2008).

The Figure 2 shows the model that gives an illustration of what is deemed as an ideal or rather effective practical design. The starting point in the model is the learning objectives that the practical activity designer has in mind which is box A. The relationship between box A what learners are expected to learn and what they actually learn is indicated as effectiveness 1. While the extent to which it helped learners to learn what was expected for them to learn depicts the relationship between box D and box A, shown as effectiveness 2. Box C shows the specific tasks that learners are expected to do during the practical lessons and box D depicts the learning outcomes of the specific tasks.

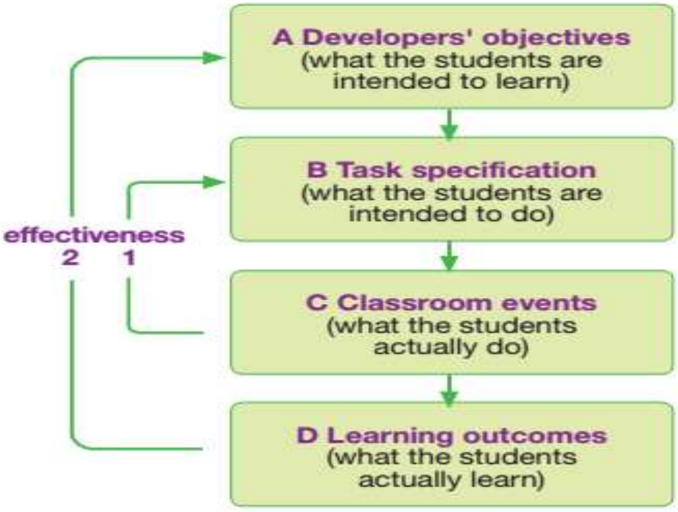

Figure 2: The process of developing and implementing a practical task

Source: Millar, Tiberghien and Le Mare̓chal (2002); Abrahams and Millar (2009:60)

Millar (2004) categorises the objectives of practical tasks into two, the category of real and observable phenomena and the category of ideas as illustrated in Figure 3.

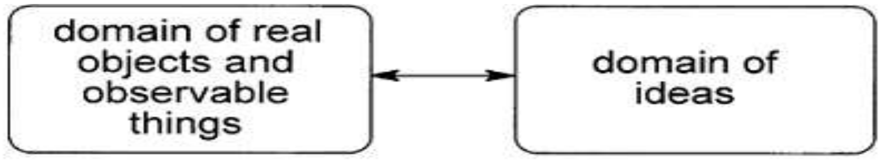

Figure 3: Practical work; linking two domains of knowledge

Source: Millar (2004:9)

Millar (2004) argues that the role of practical work is to help learners link the domain of objects and observable phenomena and events to the domain of ideas. The objectives of the first category may simply involve identifying objects and phenomena or it might involve learning a fact. On the other hand the second category can help learners to learn a concept, a relationship and a theory/model. According to Millar (2004:10) “it is unlikely that a student would grasp a new scientific concept or understand a theory or model as a result of any single practical task, however well designed”. This is supported by Mwangi (2016:21), who argues that “students acquire deeper and more extended understanding of an abstract idea or set of ideas in a gradual process, hence the need for frequent and varied practical activities”. Therefore, practical designers should design practical activities that elicit learners thinking before they make observations. Learners should be encouraged to make a prediction of the particular phenomenon first and write it down, then perform the activity and make observations and lastly explain their observations to check if they are in line with what they had earlier predicted or not (White and Gunstone, 1992).

2.5 Science Process skills (SPS)

One of the goals of doing practical work is to help students develop and acquire science process skills. These skills enable students to collect data, engage in different scientific investigations and come up with evidence to help answer scientific questions (Machina, 2012). Science process skills are divided into two classes namely; basic and integrated skills. Chemistry teachers should provide opportunities for learners to develop both basic and integrated process skills as they engage in practical activities as suggested by Muzumara (2007).The following are the SPS: Observing, Classifying, measuring, Communicating, Inferring, Predicting, using space/time relationship and using numbers are the basic process skills while identifying and controlling variables, interpreting data, formulating hypotheses, defining operationally and experimenting are the integrated process skills (Mbewe, Chabalengula and Mumba, 2010). Harlen (1997:66) holds a similar view as she indicates that "the development of ideas and understanding goes hand in hand with the development of process skills and attitudes…" Below is a brief description of each of the science process skills;

Observation

Observation is the process of using the five senses to obtain information or data about an object or event (Padilla, 1990; Chiappetta and Koballa, 2010). Therefore science teachers should plan hands-on activities that will give learners an opportunity to explore the materials and phenomena first hand (Harlen, 1998). Observation is said to have two components; the ability to notice as much detail as possible and the ability to differentiate what is related to a particular problem and what is not. This implies that pupils themselves make the observations, gather the data and think about the relationships.

Classification

Classifying is a basic science process skill, which involves grouping or ordering objects or events into categories, based on the properties, characteristics, criteria or an established scheme (Gega and Peters, 1998; Lancour 2004). Similarly, Curriculum development Centre stated that "classifying is organizing observations, ideas or events so that patterns and relationships can be detected" (CDC, 1981:15). Henceforth, pupils should be given an opportunity to observe objects or events in order to identify their similarities, differences and their inter relationships.

Measurement

This is the process of comparing things and events with the standard units using instruments (Miles, 2010). This process is important in chemistry because it enables learners to perform chemical reactions and communicate their findings in a standard and systematic manner (Machina, 2012). Pupils should therefore, be encouraged to measure different quantities using conventional units; gram, kilogram, millilitre, litre, decimetre cubed, degrees Celsius and many more. Expression of observation in quantitative terms leads to precision and accuracy in the description of phenomena.

Communication

In science, communicating means putting the information obtained from observation and investigation into some form so that another person can understand it. This is achieved by the use of diagrams, symbols, presentation of data in tabular form, graphs, charts and appropriate use of scientific concepts, laws, principles and theories (Padilla, 1990; Harlen and Jelly, 1998; Emereole, 2008). Hence forth, it is a duty of a chemistry teacher to design activities that will give learners an opportunity to share ideas, draw diagrams and use symbols.

Inferring

An inference is a suggestion, assumption or tentative conclusion deduced from observations or recorded data (CDC, 1981; Lancour, 2004). It is a process of interpreting observations or data. Miles (2010) indicates that it is important for teachers to help their learners in developing science process skills. For this reason learners should be encouraged to state their interpretations of the observed phenomena or data in tentative terms.

Predicting

Machina (2012:33) defines predicting as a "process skill that involves stating the expected outcomes of a future event based on a pattern of evidence". On the other hand some scholars (Padilla, 1990; Miles, 2010; Zeidan and Jayosi, 2015) explain that the future outcome should not be based on pattern of evidence alone but also past experience and observations. As a result, a teacher has a responsibility to design tasks that will encourage learners to make predictions based on observations, measurements and inferences.

Experimenting

This process mostly begins with an observation which suggests that questions need to be answered or a hypothesis needs to be tested. Thereafter variables must be identified and controlled, data collected, recorded and interpreted (Chiappetta and Koballa, 2010). This science process skill is complex in itself because it may involve all the other process skills (Mweshi, 2007). This implies that teachers should design practical activities that will help learners to acquire a wide range of science process skills as they engage in carrying out experiments.

Formulating hypotheses

According to Harlen and Jelly (1998:76) a hypothesis is "an attempt to explain some observation, happening or relationship". In other words it may mean stating a verifiable relationship between variables and their expected outcome in an experiment (Emereole, 2009). Formulating a hypothesis is arrived at after a careful observation and reflection. This means that phenomena should be scrutinised and then come up with a general statement based on observations. Therefore, learners should be encouraged to formulate hypotheses in all their investigations. This is the case because experimental data can either support the hypothesis or not. The role of those engaged in carrying out an experiment is to establish reasons as to why the hypothesis is or not supported.

Identifying and controlling variables

A variable is an object or quantity that can change. There are different types of variables in an investigation that must be identified and carefully controlled so that the results can only be attributed to properties or characteristics under investigation.

Padilla (1990) indicates that this process may involve identifying any other factors other than the manipulated variable that may affect the outcome of the results and keeping those factors constant for the purpose of determining causation.

Interpreting data

Data comes as numbers, graphs, charts, pictures or maps, these needs to be interpreted correctly. Interpreting data comes after processes of observing, classifying and measurements. Therefore, this process skill will enable the learners to transform data and make it more meaningful so that conclusions can be drawn from it (Emereole, 2009; Miles, 2010; Shahali et al, 2010).

Using numbers (figures)

Numbers are needed to record and manipulate measurements so as to rank objects (smaller to larger for example) as well as to classify them. The ability to use numbers is a fundamental process of science (NRC, 1996). For example, in chemistry concentrations of solutions can be expressed in numerical form.

Defining operationally

Terms in an investigation need to be defined in relation to the contexts in which they are being used. An operational definition is based on what is done and what is observed and maybe descriptive (Mbewe, Chabalenguala and Mumba, 2010).

Using space/Time relationships

All objects occupy a place in space that can be located by at least three coordinate systems (xyz) at any particular time. This process skill involves the ability to describe directions, spatial arrangements, motion and speed, symmetry and rate of change (Miles, 2010).

Mweshi (2007) carried out a descriptive survey in Kitwe district of Zambia. The study was aimed at the use of science process skills approach by Zambia Teachers Education Course student teachers. He found that majority of the student teachers understood the meaning of science process skills approach but failed to indicate the practical implications in the teaching of integrated science. This finding implies that teachers lack a clear understanding of the nature of activities that can be used to develop SPS in their lessons. However, Hodson (1998:196) argues that "Science education is not about teaching students to observe, classify, measure and hypothesise per se. They can already do that perfectly well, and have been doing so since long before they came to our science lessons". He further argues that what makes these processes scientific is the utilisation of relevant and appropriate use of science concepts. For instance scientific observation involves an application of theoretical understanding in order to recognise the features that are worth observing (Hodson, 1993). Consequently, science teachers need to provide opportunities for learners to link their observations to the domain of scientific ideas so as to enhance science conceptual understanding.

2.6 Competencies of Chemistry Teachers

The skills and competency of teachers in handling the instructional process is a matter of skilfulness in pedagogy. Teaching and learning aids are of great importance in the learning process (Katane and Selvi, 2006). On the other hand, Jimmi (2004:313) describes teachers competency as a "set of knowledge, skills and proficiency in creating meaningful experiences when organising an activity". This suggests that teacher's ability to design and deliver/implement practical work is key in enhancing conceptual understanding and development of science process skills. Central to the quality of teaching is teachers understanding of what they need to teach and the pedagogical processes that can be used to represent such understanding (Machina, 2012).

2.6.1 Pedagogical Competency

Pedagogy has more to do with understanding the relationship between teaching and learning in ways that foster learner's development and growth. It requires teachers to adopt and adapt practices that create favourable conditions for learning so as to create meaningful links between teaching and learning (Berry et al., 2001). On the other hand, Harlen (1997) describes pedagogy as the science of teaching. It consists of a number of activities such as; selection of content, formulation of objectives and selection of appropriate teaching methods. This entails that a teacher should perform these activities in order to teach effectively. Muzumara (2008), highlights some of the competencies among others that should be displayed by science teachers, these include the following; planning suitable science activities, mobilizing resources, promoting the spirit of scientific enquiry and experimentation in chemistry lessons as well as designing, identifying and implementing strategies aimed at developing science process skills.

Jimmi (2014) conducted a study on teachers' competencies in the teaching and learning of chemistry practical in Indonesia. He focused on four competencies of chemistry pedagogy that is planning, designing, implementing and evaluating practical activities. The findings revealed that teachers' level of competency in the four aspects was at both low and moderate levels respectively. Particularly, practical designing competency was found to be at 34.7%. This shows that teachers' competence in designing practical activities is at low level. Abraham and Millar (2008) claim that the effectiveness of science practical activities depends on the teacher's ability to design the practical activity and its objectives. This is affirmed by Jimmi (2014:315) who states that "teachers must be able to design and develop experiments to perform better practical in teaching. Teachers need to have a complete detail of an experiment preparation…"

A similar study was conducted in Zambia by Chocha et al (2014); the focus was on assessment of teacher competences on O-level biology practical work. The findings indicate that though teachers were able to identify apparatus and instruments used in biology, they had difficulties in relating the apparatus to the subjects in which they are frequently used. Further, the study revealed that teachers were unable to prepare meaningful practical lessons but rather replicated text book experiments. This showed that they lacked creativity, hence there is need to look at the nature of chemistry practical activities designed and delivered by Chemistry teachers in their classrooms.

2.6.2 Science Process Skills Competency

There are a number of studies that have focused on teachers' science process skills understanding. Some of these studies have emphasised the need for teachers to be competent in science process skills so that they are able to efficiently teach their learners. Emereole (2009) did a study whose focus was on the university students and senior secondary school teachers' conceptual knowledge of science processes. A three- part questionnaire was used to ascertain the participant's level of familiarity and their conceptual definitions of the science process skills. The findings of the study revealed that science teachers did not have sufficient conceptual understanding of the science process skills to help their learners to understand in a meaningful way. Further, the study established that teachers' views of familiarity did not corroborate their demonstrated ability to provide acceptable definitions of the science process skills. This is a very important finding because it shows that though teachers claimed to be familiar with the science process skills they did not demonstrate an understanding of these skills in their definitions.

A similar study was conducted by Miles (2010), it examined the in-service elementary teacher's familiarity, interest, conceptual knowledge and performance on science process skills. The participants completed a questionnaire on their familiarity and interest in the science process skills. While a test on conceptual knowledge and performance on science process skills was also done. The study revealed that teachers were highly familiar with basic science process skills but moderately interested in these skills. The results further revealed that teachers possessed very low conceptual knowledge of science process skills. This finding supports the results of Emereole (2009).

Mbewe, chabalengula and Mumba (2010) explored pre-service teachers' familiarity, interest and conceptual understanding of science process skills. The study employed a quantitative approach and a questionnaire was used to collect data. The results of this study also showed that pre-service teachers' had higher familiarity and interest levels in science process skills but very poor conceptual understanding of the science process skills. The study further revealed that the participants did not only have a poor conceptual understanding but also interchanged explicitly the definitions of some of the science process skills such as predicting and inferring.

On the other hand Shahali et al (2010) looked at primary school teacher's understanding of science process skills in relation to their teaching qualification and teaching experience. The understanding was measured in terms of conceptual knowledge and operational aspects of science process skills. A science process skills questionnaire was used to collect the data. The findings of the study indicated that teacher's conceptual understanding was very low regardless of the qualification or teaching experience. The results also showed that participants were generally aware of how to apply science process skills for science teaching but lacked conceptual knowledge of what they are and why they are important. The results seem to agree with those results obtained by other researchers (Emereole, 2009; Miles, 2010; Mbewe, Chabalengula and Mumba, 2010).

Rauf et al (2013) conducted a study in Malaysia whose purpose was to investigate whether the teaching approaches used in the teaching and learning process of a science class are able to provide opportunities to inculcate science process skills. A qualitative case study methodology was used. The study revealed that the process of teaching and learning that uses various teaching approaches in one science lesson has an added advantage of providing opportunities for the inculcation of science process skills. However, the teachers did not plan learning activities to inculcate science process skills but hoped that the skills were acquired indirectly during the lesson whether learners were aware or not.

Three categories of teachers participated in the studies reviewed above and these include; secondary school teachers, in-service elementary teachers and pre- service teachers. Regardless of the category, it is evident that teachers seemed to be lacking in their conceptual understanding of the science process skills. Therefore, they are either likely not to exhibit competence in the teaching of science using process skills approach or not use it at all. This implies that it is very difficult for teachers to come up with practical activities that maximise the development of science process skills in their learners.

2.6.3 Science Knowledge and Understanding Competency

One of the characteristics of effective science teachers is a deep understanding of science concepts. The ability to identify, explain and apply concepts is critical in designing, delivering and assessing instruction (McConnell, Parker and Eberhardt, 2017). An assessment of teachers' science content knowledge was conducted by McConnell, Parker and Eberhardt (2017). The study used pre-post instruments in eight knowledge strands and compared the responses across teachers. The instruments focused on assessing both general knowledge and the ability to apply big ideas related to specific science topics. The findings revealed that teachers possessed weak content knowledge in some areas of science. In most cases teachers focus was on providing learners with factual knowledge in a number of topics and expect them to memorise scientific definitions. There was no meaningful teacher to learner or learner to learner interaction (Kurup, 2014). Similarly, Nixon, Hill and Luft (2017), embarked on a longitudinal study whose focus was secondary science teachers' subject matter knowledge development across the first five years. The results indicate that new chemistry teachers' subject matter knowledge did not change significantly from their first year of teaching to their fifth year of teaching. This implies that chemistry teachers have insufficient subject matter knowledge to enhance conceptual understanding of chemistry concepts.

Most of the studies reviewed have acknowledged the importance of practical work in the teaching and learning of chemistry and science in general. However, they have not conclusively provided answers to questions relating to the nature and level of creativity in chemistry teacher designed practical work. This indicates a knowledge gap in these studies. The methodologies used have focused so much on self-reports through the use of questionnaires, but teachers do not always do what they say. Thus, the current study employed methods that focused more on understanding teachers' competence in the design and delivery of chemistry practical work by visiting and observing practical lessons in their natural setting so as to contribute to the body of knowledge.

2.7 Summary of Literature Review

The chapter focused on the role of practical work, the nature of practical work and the ideal design and delivery of practical activities as proposed by scholars. The chapter also looked at the literature on science process skills as well teachers' pedagogical competency and science knowledge and understanding competency. It became apparent from literature reviewed that practical work is important in the teaching and learning of chemistry and science in general. The literature also established that the nature of practical activities as practiced in secondary schools is somehow limiting and does not promote learners science knowledge construction and conceptual understanding. However, there seems to be emphasis on the aspect that the effectiveness of these science practical activities depends on the teacher's ability to design and develop appropriate and clear objectives. The next chapter describes the methodology that was used in this study.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the research methodology. It describes the philosophical underpinning and approach guiding the study, research design, study site, target population, study sample, sampling procedures, research instruments, data collection procedures and how data was analysed.

3.2 Philosophical Underpinning and Approach of the Study

The study used qualitative approach. There are a number of strengths of qualitative approach such as the active role of the researcher to gather detailed information of the participants' experiences of a particular phenomenon. This may be done through examining documents, observing behaviour or interviewing participants (Merriam, 1998). This increases the depth of understanding of the situation about a much smaller number of participants but reduces generalizability (Patton, 2002). Secondly a qualitative researcher tries to develop a complex picture of the problem under study. This involves reporting multiple perspectives and identifying many factors central to the phenomenon. This provides a holistic account of the problem under study (Creswell, 2014). Thirdly, qualitative approach allows for gathering of multiple forms of data from multiple sources such as interviews, observations, documents and many more rather than relying on a single data source. The number of strengths highlighted above is in line with the assumptions of the interpretivism philosophy.

This study was underpinned by the philosophy of interpretivism. The proponents of this philosophy put forward a number of basic ideas such as individuals seek understanding of the world in which they live and work. The other aspect is that in order to understand phenomena the researcher needs to understand the world from the participant's perspective within their natural setting (Saunders et al., 2012). As a result, individuals develop subjective meanings of their experiences directed at certain objects or things (Creswell, 2014). Thus, the role of the researcher is to interpret the views or experiences of the participants and ascribe meaning to them.

3.3 Research Design

A case study design was employed in conducting this study. A case study focuses on a single unit to produce an in-depth description that is rich and holistic. A unit can be an individual, a group, a site, a class, a policy, a process, an institution, a community or town (Merriam, 1998). This study used geographical parameters as definition for a unit (Cohen, Manion and Morrison, 2007). The design also allowed the researcher to collect detailed data using a variety of data collection instruments and procedures (Yin, 2012). The study used observations, semi- structured interviews, focus group discussion and document analysis. The objective of the study was to determine the nature of Chemistry practical activities designed and delivered by Chemistry teachers. As a result lesson observation schedule was used during the classroom practical activities, documents such as the Chemistry syllabus, practical activity worksheet were analysed. In addition, interviews were conducted with the teachers and focus group discussions were also done. This provided an opportunity to warrant trustworthiness and credibility of data through triangulation. Hence forth, case study design was an appropriate design for this study because basic to it is the use of multiple data collection tools.

3.4 Study Site

The study was conducted in Kitwe District of Copperbelt Province of Zambia. The district is located about 290 kilometres north of Lusaka the capital city of Zambia. The district was chosen for the study because it has a number of public secondary schools that have functional laboratory facilities. The study was done in three selected secondary schools in the district as shown in Figure 4.

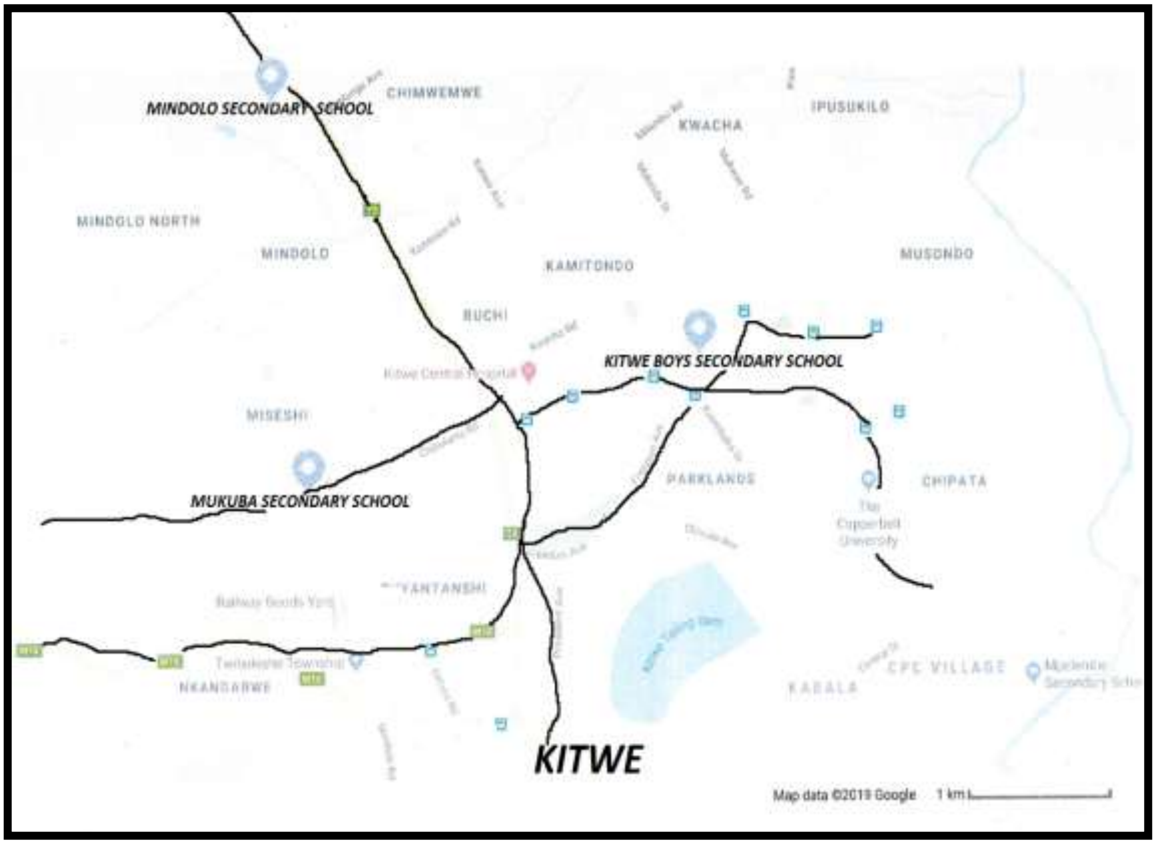

Figure 4: Sketch map of Kitwe district and study locations

Source: Google Maps (2019)

3.5 Study Population

This study targeted Chemistry Teachers teaching the two chemistry syllabi (5070) pure Chemistry and (5124) Science (a combination of Chemistry and Physics) in selected secondary schools in Kitwe district of the Copperbelt Province of Zambia. The chemistry teachers in these schools were chosen because the schools had operational science laboratories and they were ready to be observed during their Chemistry practical activity lessons. In order to get more comprehensive data, the study included pupils from the respective classes where lesson observations were done.

3. 6 Study Sample

The study sample comprised 6 chemistry teachers and 24 pupils drawn from three secondary schools that offer pure Chemistry (5070) and Science (5124) syllabi. The sample was representative enough considering the nature, purpose and data collection methods such as observations that require a lot of time (Ary, Jacobs and Sorensen, 2010). If a larger sample was used, it would have been problematic to triangulate data collected using multiple data collection techniques.

3.7 Sampling Techniques

In this study purposive sampling was used to select the six Chemistry teachers. The six teachers were selected because they had both pure chemistry and science grade 11 classes. The researcher was satisfied that this technique provided a sample of participants that were information-rich about practical work. Though there are a number of purposive sampling techniques used in qualitative research as described by Marshall and Rossman (2011), this study specifically used homogenous sampling. This is because only those teaching grade 11s participated in the study. The 24 pupils were selected from the classes where lesson observations were done based on their participation during the practical activity lesson. Grade 11 pupils were preferred in this study because at this level they had acquired the skills in the handling of apparatus and chemicals involved in Chemistry practical activities.

3.8 Research Instruments

The objectives of the study provided the foundation from which the instruments were designed. The following instruments were used to collect data;

3.8.1 Observation Schedule

This is one of the instruments used in collecting qualitative data. It gives the researcher an opportunity to have a complete description of behaviour in a specific setting (Ary, Jacobs and Sorensen, 2010). The instrument was designed by the researcher in such a way that it captured all the three objectives of the study. It was used to monitor four aspects that is; nature of chemistry practical activities, range of science process skills developed through chemistry practical activities, level of creativity and actual classroom actions (Appendix B).

3.8.2 Document Analysis Schedule

The various documents were analysed so as to gain a deep understanding of the phenomenon under study. Patton (2002) indicates that documents provide the researcher with information about many things that cannot be observed. The focus was to analyse the chemistry syllabi, the chemistry schemes of work, the chemistry lesson plan and the chemistry practical activity worksheets. The syllabi was analysed by locating the part where the observed practical activity came from, ascertaining whether the objectives are measurable and attainable and looking at other practical activities suggested for the topic. While a scheme of work was used to check for frequency of practical activities as one of the teaching and learning strategy.

Practical activity worksheet was examined in terms of clarity of aim for the activity, safety rules, level of material and apparatus improvisation and data analysis questions for practical activity (Appendix C). This instrument was developed by the researcher.

3.8.3 Semi-structured Interview Schedule

The semi-structured interview schedule was developed by the researcher and it was composed of five open ended questions. It was meant for chemistry teachers in the three selected secondary schools. The questions in this instrument were used to follow up on the objectives of the chemistry practical activities, how science process skills development was enhanced during chemistry practical lessons and the considerations made when designing chemistry practical activities (Appendix D).

3.8.4 Focus Group Discussion Guide

Focus group discussion is described as a more socially, flexible and open in nature tool. It provides an opportunity for the researcher to get a variety of perspectives on the topic under study (Ary, Jacobs and Sorensen, 2010). The instrument had six questions however; its main focus was to clarify specific matters that arose from observations and document analysis (Appendix E).

3.8.5 Validation of Research Instruments

Validity is defined as the extent to which an instrument measures that which it claims to measure (Ary, Jacobs and Sorensen, 2010). In this study the instruments were validated through review by others. After the instruments were developed they were reviewed by peers and supervisors who are experts in the field of science education.

For instance certain descriptors that were deemed unnecessary were removed from the observation schedule and replaced with those that were more succinct. Their comments were helpful in improving and sharpening the instruments so that they were appropriate to collect the data needed to achieve the objectives of the study.

3.9 Data Collection Procedure

Permission to conduct the study at the three selected secondary schools was sought from the respective Head Teachers. The researcher reported to the Head Teachers and presented an introductory letter obtained from the Directorate of Research and Graduate Studies of the University of Zambia through the Office of Assistant Dean Postgraduate in the School of Education. The letter introduced the researcher as a student and stated the purpose of the study. Then the Head Teachers introduced the researcher to the Heads of Science Department. After which, the researcher was able to meet the chemistry teachers with the help of the Science Heads of Departments bservation and interview appointments were made with the participants according to their usual teaching time tables.

The first activity was lesson observation, the researcher observed twelve lessons in total. Each participant was observed twice in an eighty minutes practical work lesson. When invited to class the researcher sat quietly at the back filling the observation schedule without interfering with the progress of the lesson. The observations focused on the nature of practical activities, the range of science process skills developed, the level of creativity in practical activities and the actual classroom actions by both the teacher and learners during the practical activity. The observations were also video recorded. At the end of each observation the researcher had a focus group discussion with the learners. This was aimed at getting their perspectives on the practical activity they had just done.

Secondly, document analysis proceeded simultaneously with observation. This was the case because at the end of the first observation for each participant the researcher managed to collect a copy of the schemes of work, lesson plan and practical activity worksheet used in the observed lesson. Interviews with the teachers were one to one and they were conducted by the researcher herself. The proceedings of the interviews were jotted down in the spaces provided in the interview schedule as well as audio recorded.

Focus group discussion for teachers was the last activity to be conducted. This was done by inviting the six participants to one school. The main focus of this activity was to clarify specific matters that arose during lesson observations. Additionally, it was also used as a platform for the participants to share a variety of perspectives on the topic under study. The researcher regulated the deliberations ensuring that each member had an equal opportunity to share his/her view. A focus group discussion schedule was used as a guide, the discussion was video recorded and it lasted for two hours. Taking into consideration ethical issues, the schools were identified by numbers (1, 2 and 3) while participants were identified by letters (A, B, C, D, E, F). The entire data collection process lasted for seven weeks and it was done in the third term of 2017.

3.10 Data Analysis

The data collected from observations, interviews, document analysis and focus group discussions was analysed in line with research objectives and questions. Firstly, the data was organised this was done by transcribing interviews, focus group discussions, information from document analysis. For lesson observations the videos were played back and forth then transcribed, these transcriptions were then compared with what was recorded on the observation schedules. At this point the researcher was indicating notes and points alongside what was recorded in the observation schedule during observations. After which data was sorted and put into different categories depending on its sources that is the instruments. Secondly all the data was read in order to get a general sense of it, this accorded the researcher an opportunity to reflect on its overall meaning and implications (Merriam, 1998; Creswell, 2014). Thirdly, data from various sources was read several times and then organised into categories based on its meaning and implications after which major themes were generated.

3.11 Ethical Considerations

Permission to conduct the study in the three schools and gain access to the participants was sought from their respective Head Teachers. This was by means of presenting a letter from Directorate of Research and Graduate Studies of the University of Zambia through the office of Assistant Dean Postgraduate in the School of Education. The letter introduced the researcher as a student and stated the purpose of the study. The participants were informed about the nature of the study and their rights to withdraw from the study at any particular point were respected. Permission was also obtained to videotape the practical activity lessons. Confidentiality, anonymity and privacy of the participants were assured. This was achieved by keeping their identities anonymous throughout the study. To protect the video tapes a folder and a password key were created and only the researcher had knowledge of this password key. Further, the data that was collected was held confidential and was not to be used for any purpose other than achieving the objectives of the study.

3. 12 Summary of the Methodology

The chapter discussed the research design, the population and sampling procedures. Additionally, the philosophy that informed the study, research instruments, data collection procedures and analysis procedures were also explained. Practical work observations were done, followed by semis-structured interviews. Focus group discussions and document analysis were also done. The results obtained will now be presented in the next chapter.

CHAPTER FOUR: PRESENTATION OF FINDINGS

4.1 Introduction

This chapter presents the findings according to the study objectives namely;

(a) To determine the nature of Chemistry Practical Activities designed and delivered by chemistry teachers.

(b) To establish the range of Science Process Skills developed through chemistry teacher designed practical activities.

(c) To describe the level of creativity in teacher designed Practical Activities.

4.2 Nature of chemistry practical activities designed and delivered by chemistry teachers

To ascertain the nature of practical activities designed and delivered by chemistry teachers the study focused on the following aspects: objectives of the practical activities designed by teachers, the type of practical activities and the purpose of these practical activities.

4.2.1 Objectives of the practical activities designed by chemistry teachers

A total of 12 practical lessons were observed, eight of these lessons had clearly stated objectives and were achievable. Teacher A (TA) for example, designed a practical activity on quantitative analysis (volumetric analysis) and had the following objectives: (a) to titrate and find the volume of hydrochloric acid (HCl) which reacts with 25ml of sodium hydroxide ($NaOH$), (b) to write a balanced chemical equation for this reaction. On the other hand four of the practical lessons observed had no stated objectives. When the practical activity worksheets were analysed for the observed lessons two sets of practical worksheets emerged. One set composed of past examination practical activities worksheets that were adapted for the classroom situation by the teachers by adding objectives and materials to use. The other set was composed of past examination practical papers photocopied and distributed to the learners or written on the chalkboard.

Nonetheless, when asked what their practical activities were intending to achieve, the participants indicated that objectives are very important in the teaching of chemistry as a whole. For example participant B said "… the work sheet has to go hand in hand with the objectives that you want to achieve, the objectives will be more like a guide".

Teacher C said:

> …of course every practical should have objectives, something that you want to be achieved by the end of the day. I think I had the main objective of helping learners to prepare a salt and evidence of attainment was seeing pupils identifying reagents and able to conduct the experiment successfully.

It is important to note that even those participants who used practical examination past papers as worksheets without any modifications did highlight the importance of objectives. During the interview when asked about the aspects to consider when coming up with a practical activity worksheet one of the common response was "… as you observed the main objective was to prepare my pupils for the final exam".

The findings may seem to indicate that the focus of most of the practical activities was to prepare the learners for the examination. The study also revealed that the participants appreciated the importance of objectives in their practical activities but interpreted them or rather used them according to their own understanding. Referring back to the reasons stated by the teachers above, their understanding was that as long as learners manipulated the materials and pieces of apparatus, then the practical activities were successful. This was premised on the fact that they are likely to do the same during the final examination chemistry practical. It can further be noted that those who designed worksheets or modified practical past examination papers activities for their lessons made an effort to state the objectives for their practical activities. However, the stated objectives were an indication of procedural type of practical activities.

4.2.2 Types of Practical Activities Designed by Chemistry Teachers

The study mainly used lesson observation to establish the types of practical activities designed and delivered by the chemistry teachers. The lesson observations were complimented by focus group discussions so as to get insights of both teachers and pupils actions and focus as they conducted the hands-on activities. The results are shown in Table 4.1.

Table 4.1: Types of practical activities designed by chemistry teachers

Characteristics of practical activity	**Type of practical Activity**	**Frequency**
• Pupils following a list of steps provided by teachers • Pupils not allowed to come up with an alternative method • The required reasonable amount of time given to learners to do the activity	Procedural	11

• Pupils do a specific task that is easily organised by the teacher • Pupils manipulate limited materials and apparatus • Teacher may do the activity alone as a demonstration or choose some pupils to do so • Pupils working towards confirming an idea	Illustrative	0
• Teacher presents a scientific problem to learners • Teacher providing various materials and apparatus for pupils to use • Pupils openly using various procedures to conduct the activity • Learners working towards solving a problem with less guidance from the teacher.	Investigative	1

From Table 4.1, it can be seen that out of the 12 practical lessons observed and worksheets analysed 11 were procedural and only one was investigative. Pupils were guided by an outlined number of steps to follow when conducting practical activities. It was also observed that learners were working in small groups. When asked during the focus group discussion which is better, working in groups or individually. Learners responded that working in small groups is better compared to working individually because they were able to share ideas and it also helped them to finish the task on time.

It was also observed that those classes that were doing the pure chemistry (5070) syllabus handled the apparatus appropriately as compared to those who were doing science (5124) syllabus. When teachers were asked why this was the case, they indicated that learners who did pure chemistry (5070) were exposed to practical activities in order to prepare them for practical examination. But those that took science (5124) were just getting exposed because practical examination was just recently introduced. Though teachers presented their procedures in various ways to the learners such as using a work sheet, writing on the chalkboard or simply giving copies of past examination practical papers to the learners, the teachers in most of the observed lessons took time to explain the procedure to the learners.

During a focus group discussion with the teachers to discuss matters that arose during the observations, teachers were asked to indicate what they thought as the best way of presenting practical activities. The common response was that learners should do the practical activity by following guiding steps. For example Teacher D (TD) stated that:

> The best way of delivering practical activity is to allow pupils to carry out the experiment themselves and a worksheet is necessary because they have to follow instructions. They should have a feel or hands-on experience but this has to be guided so that we do not waste a lot of time...

A similar view was expressed by pupils during the focus group discussion, one pupil stated:

> …I like practical activities with instructions; it can be very frustrating if we are not given steps and keep on trying and trying wasting time… However, another pupil thought; … I feel it can be fun to discover things for ourselves and try out other ways of getting it done, always following teacher's steps is not fair.

The researcher also took a close look at the worksheets that were given to the learners. It was observed and it became apparent that the worksheets had an outline of steps to follow by the learners. From the document analysis eight practical activity worksheets were prepared by the teachers for their practical activities. The worksheets had an outline of steps to follow by the learners when conducting the practical activities. During the interviews and focus group discussion teachers disclosed that preparing worksheets for their practical lessons was helpful in saving time needed for the lesson. For example, Teacher E (TE) added that:

> …I prepare my worksheet a day before the practical lesson so that I can check for the chemicals available in the lab and apparatus. This will help me to know if it is going to be pair or group work and also the number of working stations.

The use of past paper examination was another way that was used to guide learners when doing a practical activity. About eight teachers prepared practical activity worksheets while four teachers used past examination practical activities. The teachers made copies of the past practical examination papers and distributed them to the learners in groups. It is worthy to mention here that the examination hands-on activities were procedural in nature just like the ones prepared by teachers. This was the case because past examination practical activities were used as blue prints by teachers for their activities. This was revealed by document analysis of practical activity worksheets. Additionally, this observation was reinforced by some of the comments made by the teachers. For instance, TA pointed out that:

> When you are doing qualitative analysis and volumetric analysis which are the key practical activities in chemistry you can refer to a past paper. If you have already handled the theory part it will be very difficult to write a worksheet because it will be more like a lesson, so you give them the past paper there is a guide of how to handle the same practical.

In some cases the practical procedures were written on the chalkboard by the teachers. They felt it was a good idea for the learners to copy the practical procedures in their books before doing the actual practical activities.

The findings suggest that chemistry teachers depended on past examination practical activities for their practical lessons. Certainly this is indicative of the type of practical activities designed by teachers for their learners. However, using a practical work sheet was more economical in terms of time compared to the other forms and it also gave the teacher an opportunity to prepare in advance before the practical lesson. The findings further seem to suggest a deductive approach in the execution of practical activities. The teachers introduced the phenomena, explained it and then expected learners to complete the tasks so as to practice and experience the phenomena. Additionally, the teachers were more active in the learning process as they gave instructions to the learners and learners were simply expected to follow the instructions as the carried out the practical activities.

It is also important to note that the objectives of most of the practical activities observed clearly points to the nature and type of practical activities designed by chemistry teachers. For instance, some of the objectives highlighted are a clear indication of procedural type of practical activities. It also exposes some of the aspects that teachers focus on during the planning stage of their practical activities. It can be deduced that during the planning stage the focus was to check on the availability of materials, to determine whether the practical activity will be done in groups or pairs and the time available. This shows that mostly teachers did not focus on how learners will be engaged in the practical activities so as to help them understand the concepts.

4.2.3 The Purpose of Practical Activities Designed by Teachers

It was observed that the purpose of the practical activities designed by the chemistry teachers was either to expose the learners to pieces of apparatus and their use so that learners will be able to manipulate them later on or to confirm what was discussed in the theoretical lessons to actually see what happened during the practical activities. Interviews were used to follow up these observations. The participants were asked what the purpose of their activities was and the following responses stood out;

Teacher B (TB) said that:

> Learners learnt how to handle the apparatus, some of them did not even know the parts of the apparatus that they were using but at least at the end of the experiment they were able to know which one is which. Which one is used for pipetting, which one should be used for titrating.

A similar view was expressed by Teacher F (TF):

> Doing a hands-on activity lesson the learners will get used on how to handle the apparatus, handle the chemicals they will learn how to make observations and record them. Unlike when you just come with the apparatus yourself and do a demonstration, when you allow the pupils to have a feel of the apparatus and the chemicals they will be used and in the long run they will be able to do it even if you just give them a worksheet

On the other hand, Teacher A pointed out that:

> Sometimes it helps in consolidating certain learning concepts that the children learn. When you talk about them in theory it is from some kind of abstract situation, now when you do it in the actual practical, when I

> say the colour outcome will be blue or yellow they will be able to see that and appreciate it.

In the same line Teacher C stated that:

> I think it was more like a consolidation of what they have in class to match with actually what they were able to see. Some especially the reactions that were producing bubbles I think they saw from there that a reaction is taking place here and it helped them to even concretise on what they theoretically knew happening in practical…

Certainly from the comments, it can be claimed that the practical activities designed by chemistry teachers were only used to confirm what was discussed during theory lessons. As long as learners carried out the practical activities following laid down steps and they were able to handle the pieces of apparatus properly then the practical lesson was successfully taught.

Further, when participants were asked how the practical activities they designed helped the learners to link practical to real life situations, the participants disclosed that sometimes they did not mention the applicability aspect of practical activities to the learners. For instance Teacher E stated that:

> We are supposed to tell them at the end of that practical because some of the pupils will be working in industries. A practical like quantitative analysis they will be able to use the same skill in the analysis of ferrous in a ferrous carbonate that is done in industries. But sometimes we forget to tell our pupils how those practical activities will help them, I feel it is really important that we do that.

Nevertheless, during lesson observations there was no question that could have helped the learners to link the practical activity to real life situations. Thus, they did not show a realisation that there was a link whatsoever between the practical activity they were doing and real life situations. Document analysis of lesson plans and worksheets did not show practical activities objectives that would have helped the learners in the realisation of the link between practical activities conducted and real life situations. It can be stated that objectives are an important aspect of practical activity designing because they can tell us more about the nature and purpose of the activity. On the other hand, during focus group discussions participants indicated that most of the lesson plan format they use has a component called the rationale. Under this component they try to show the importance or rather the link between the lesson and the real life situations. On the contrary most of the lesson plans analysed did not have this component stated.

This shows that teachers acknowledged that practical activities should help learners apply scientific knowledge to real life situations. However, their practical lesson plans did not reflect how they intended to do so. Similarly, the practical worksheet designed for their lessons did not show how learners were helped to link practical to real life situations and even their objectives were not aligned for that purpose. It was also interesting to note that some of the worksheets did not even show the objectives of the practical activities that were done.

4.3 Range of Science Process Skills developed through Chemistry Teacher designed Practical Activities

To determine the range of science process skills developed through chemistry teacher designed practical activities, the study focused on the number of the science process skills reflected in each practical activity and whether or not teachers were not aware of the process skills learners needed to use in order to understand the concepts/ideas. The data was obtained through various ways namely: observations, worksheet analysis, interviews and focus group discussions. Table 4.2 shows the science process skills that were generally reflected in the practical activities observed

Table 4.2 Science process skills observed in teacher designed practical activities

Number	***Science process skills***	***Observed***
1	Observation	✓

2	Classification	✓
3	Communication	✓
4	Measuring	✓
5	Predicting	✗
6	Inferring	✗
7	Using numbers	✓
8	Identifying and controlling variables	✗
9	Interpreting data	✓
10	Formulating hypothesis	✗
11	Defining operationally	✗
12	Experimenting	✓

A tick (✓) indicates that a particular science process skill was observed in a practical activity while a cross (X) denotes the absence of that particular science process skill. Out of the 12 sciences process skills seven were observed as shown in Table 4.2. It can also be noted from the results that out of the seven science process skills reflected in the observed practical activities five were basic science process skills (observation, classification, communication, measuring and using numbers) and only two (interpreting data and experimenting) are integrated science process skills. This finding suggests that the practical activities designed by chemistry teachers focused on the development of basic science process skills rather than an integration of both basic and integrated science process skills. This was so due to the nature and purpose of these practical activities.

Tables 4.3, 4.4 and 4.5 show the range of science process skills developed through chemistry teachers designed practical activities on specific topics that were observed.

Table 4.3: Range of science process skills developed through qualitative analysis practical activity

Practical activity	***Science process skills***	***Observed***
A Qualitative s Analysis (Identification s of cations & anions) h o w	Observation	✓
	Classification	✓
	Communication	✗
	Measuring	✗
	Predicting	✗
	Inferring	✗
	Using numbers	✗
	Identifying and controlling variables	✗
	Interpreting data	✗
	Formulating hypothesis	✗
	Defining operationally	✓
	Experimenting	✓

As shown in Table 4.3, four science process skills were developed through this practical activity. During lesson observation and document analysis of the practical activity worksheet it was clear that learners were making observations as they conducted the activity. They were able to observe the colour changes of the various substances, classify the substances as either cations (positively charged ions) or as anions (negatively charged ions) based on certain colour patterns. Communication was also developed through this activity because learners were discussing in groups the appropriate colour change and also completed their data collection tables. Lastly, experimenting (as they made observations, collected data and manipulated the materials and apparatus) was developed as they engaged in the practical activity. It is clear that this practical activity developed mostly three basic science process skills compared (1) to integrated science process skills.

Table 4.4: Range of science process skills developed through volumetric analysis practical activity

Practical activity	*Science process skills*	*Observed*
Volumetric Analysis (titration)	Observation	✓
	Classification	✗
	Communication	✓
	Measuring	✓
	Predicting	✗
	Inferring	✗
	Using numbers	✓
	Identifying and controlling variables	✗
	Interpreting data	✓
	Formulating hypothesis	✗
	Defining operationally	✗
	Experimenting	✓

Table 4.4 shows that the practical activity on volumetric analysis developed a number of science process skills. Learners were making observations as they tried to establish the end point of the reaction between a base and an acid. Communication was also used or rather developed during this activity as learners were engaged in small group discussions and filled in a table of results. Measuring was key for this practical activity, an exact amount of 25 ml of the base was transferred from the beaker into the conical flask for titration. Numbers were used as they recorded the

volume of the acid used from the burette. The data was interpreted following guiding questions on the worksheet. For example, "find the volume of hydrochloric acid (HCl) that reacted with 25 ml of sodium hydroxide (NaOH)". Experimenting was also

reflected as it was the medium through which other science process skills were developed.

Table 4.5: Range of science process skills developed through preparation of soluble salts practical activity

Practical activity	***Science process skills***	**Observed**
Preparation of soluble salts	Observation	✓
	Classification	✓
	Communication	✓
	Measuring	✗
	Predicting	✗
	Inferring	✗
	Using numbers	✗
	Identifying and controlling variables	✗
	Interpreting data	✓
	Formulating hypothesis	✗
	Defining operationally	✗
	Experimenting	✓

As shown in Table 4.5, the preparation of a soluble salt practical activity developed a total number of six science process skills. Out of the six, four were basic science process skills while two were integrated science process skills. The basic science process skills developed in this activity were; observation, classification and communication. Interpreting data and experimenting were the integrated science process skills used. During the practical activity, it was observed that learners used observation when they added the metal oxides (Lead oxide and cupric oxide) as well as when they added the metal carbonate to nitric acid (HNO_3). They took note of the colour changes, presence of bubbles and effervescence. Classification was used based on the observed patterns and characteristics of the reagents and products.

Communication was oral and it was observed when learners where arguing about the colour change. Though there was no measurement done in this practical activity, interpreting data was used based on observation and classification. For instance, there was a guiding question on the practical activity worksheet, "identify the name of the gas produced when necessary".

The results from Tables 4.3, 4.4 and 4.5 revealed that teacher designed practical activities did not develop the same number of science process skills. This may be dependent on the topic, the creativeness of the teacher in designing the practical activity worksheet that maximises the number of science process skills developed by the learners.

Table 4.6 A comparison of observed science process skills across the observed practical activities

Observed process skill	*Activities (12)*	*Frequency*
	Volumetric Analysis	4

Observation	Qualitative Analysis	6
	Preparation of Salts	2
Classification	Volumetric Analysis	0
	Qualitative Analysis	6
	Preparation of Salts	2
Communication	Volumetric Analysis	4
	Qualitative Analysis	6
	Preparation of Salts	2
Measuring	Volumetric Analysis	4
	Qualitative Analysis	0
	Preparation of Salts	0
Using numbers	Volumetric Analysis	4
	Qualitative Analysis	0
	Preparation of Salts	0
Interpreting data	Volumetric Analysis	4
	Qualitative Analysis	0
	Preparation of Salts	0
Experimenting	Volumetric Analysis	4
	Qualitative Analysis	6
	Preparation of Salts	2

Table 4.6 shows that observation, communication and experimenting were developed in all the 12 practical lessons observed. This was followed by classification that was observed to be used by the learners eight times, measuring was used four times. Measuring was observed to be used mostly in volumetric analysis practical activities. Using numbers and interpreting of data was used or rather observed four times, these science process skills were used or reflected in the volumetric analysis as opposed to practical activities based on qualitative analysis. In all the 12 practical activities

observed learners were engaged in experimenting by manipulating apparatus and materials. Predicting, inferring, identifying and controlling variables, formulating hypotheses and defining operationally were not reflected in all the 12 practical activities observed. The study revealed that practical activities designed by chemistry teachers provided for the development of mostly the basic science process skills as compared to integrated science process skills. This has implications on the nature of chemistry practical activities developed by the teachers for their lessons.

4.4 Level of Creativity in Designing Chemistry Practical Activities by Chemistry Teachers

To ascertain the level of creativity in the design and delivery of chemistry practical activities by teachers, the study focused on the originality of the task and the level of improvisation. Data came from the following sources; observations, focus group discussion, document analysis of practical activity worksheet, schemes of work and the chemistry syllabi.

4.4.1 Originality of the Task

The task was analysed by looking at the objectives and the variety of practical activities that were designed by teachers for their lessons. It was observed that most of the tasks were obtained from past practical examination papers. The only variations were that some teachers took time to adapt the past paper examination activities by stating the objectives and the materials to be used for that particular activity. Conversely, some tasks were simply past examination practical activities without any modifications for the classroom situation.

Results have already shown that the three types of activities were conducted namely; volumetric analysis, qualitative analysis and preparation of salts. When worksheets for the 12 practical lessons observed were analysed, certainly three categories emerged and these were; volumetric analysis, qualitative analysis and preparation of salts. The document analysis indicated that the chemistry (5070) and science (5124) syllabi actually recommends a number of practical activities for these topics even for other topics as well.

During the focus group discussions, the participants were asked why they opted to prepare practical activities only from the earlier alluded to practical activities. They responded that they did practical activities to prepare learners for the examinations. For example, Teacher E stated that "we only focus on qualitative and volumetric analysis because these are the only practical activities that come in the exam. Believe you me even if I have not seen the advance copy for this year, I know that titration is there''. This seems to suggest that, the teacher designed tasks that are not original because they are either modified past examination practical paper or simply unmodified past examination practical activities. Further, the three categories of the tasks were selected to be given to the learners based on the premise that they are the ones that come in the examinations. This lack of variety in the practical activities designed by teachers may be attributed to lack of creativity and innovation.

4.4.2 Level of Improvisation

This was achieved by looking at the concepts that were being explored by the learners in the practical activity and the appropriateness of the pieces of apparatus and materials for that particular task. For instance, during the identification of ions learners were required to use the following apparatus; test tubes, test tube racks, beakers and pipette droppers. All these pieces of apparatus were provided for the learners to use during the task. Therefore, there was no need for improvisation in terms of apparatus because they were available. However, it was observed that teachers were in a position to provide alternative conventional pieces of apparatus available to help learners conduct the practical activity successfully. During a volumetric analysis practical activity, learners were required to use a pipette and pipette filler to transfer the base from the beaker into a conical flask but these pieces of apparatus were not available. The teacher provided a 25ml measuring cylinder instead. This was a good option because learners were able to do the task successfully. This was affirmed by Teacher B who said that:

> Sometimes it may be specified that use a pipette and pipette filler but if you do not have that you cannot just stay and say I do not have a pipette and pipette filler, I will not teach the pupils this practical lesson. You have to think of other apparatus that you can use for example you can use a measuring cylinder in place as you look for the pipette itself, so a substitute apparatus can be used.

When teachers were asked about the importance of improvisation in the teaching of chemistry particularly practical activity lessons, they were quick to respond that it is very important. However, Teacher D said, “there are certain things that we can improvise and that we cannot. It is very difficult to improvise chemicals for example how can you improvise magnesium metal or sodium hydroxide surely, these should just be present”.

The results illustrate that teachers appreciate the importance of improvisation in their chemistry practical lessons however their improvisation was only at the level of apparatus. Thus, they seemed not ready to go a step further in coming up with alternative pieces of apparatus or some chemicals that are not available in their laboratories.

4.5 Summary of the Findings

The findings chapter has shown a number of things as outlined in the following subsections.

4.5.1 Nature of Practical Activities Designed by Chemistry Teachers

- Most of the practical activities designed and delivered by chemistry teachers were procedural because they were characterised by learners following laid down procedures.

- The focus of most of the practical activities was to prepare the learners for the examination.

- The focus was on the practicalities of the task not on how the task helped the learners to understand the chemistry concepts. This was the case because participants indicated that their activities were successful.

4.5.2 The Range of Science Process Skills developed through Teacher Designed Chemistry Practical Activities

- Chemistry practical activities focused mostly on the development of basic science process skills as opposed to the development of integrated science process skills.
- Teachers did not ask questions that would have focused and engaged learners in the use of other process skills as they collected and analysed data.
- They lacked the knowledge of the process skills approach in the teaching of chemistry. As a result they did not provide opportunities for the development of a wider range of science process skills.
- The activities were procedural and so integrated process skills would not be developed.

4.4.3 Level of creativity in teacher designed chemistry practical activities

- The practical activities lacked originality, because the teachers used past examination practical activities. There was also lack of variety in the activities given to the learners, pointing to lack of creativity in the designed practical activities
- Teachers' ability to improvise was inadequate as they were not able to come up with alternative pieces of apparatus not available in their laboratories.

The next chapter presents the discussion of findings

CHAPTER FIVE: DISCUSSION OF FINDINGS

5.1 Introduction

This chapter presents the discussion of the findings of the study. The discussion is presented according to the following major themes of the findings; the nature of chemistry practical activities designed and delivered by teachers, the range of science process skills developed through practical activities designed by teachers and the level of creativity in teacher designed chemistry practical activities.

5.2 Nature of chemistry practical activities designed and delivered by chemistry teachers

There are various categorisation of practical work as used in secondary schools. Wellington (2002) highlights a number of them such as; teacher demonstrations, class practical activity and learners working on similar tasks individually or in small groups. To establish the nature of practical activities designed and delivered by chemistry teachers the study focused on the following aspects; the objectives of the practical activities, teachers and learners role during the activities, purpose and scope of the activities. The findings of the study indicated that the focus of most of the practical activities was to prepare the learners for the examination. However, practical activities are very important in the teaching and learning of chemistry concepts. For this reason teachers should have a clear role of the practical activities that they give to their learners. This is also echoed by Abraham and Millar (2009) that there is need for teachers to have a clear understanding of the reasons for doing practical work.

For instance Teacher C stated that:

> Of course every practical should have objectives, something that you want to be achieved by the end of the day. I think I had the main objective of helping learners to prepare a salt and evidence of attainment was seeing pupils identifying reagents and able to conduct the experiment successfully.

This comment is indicative of an investigative type of practical activity because there is an aspect of learners being able to identify the appropriate reagents and conduct the experiment successfully.

Though the activities had objectives, in terms of cognitive level the objectives were at low level if ranked on the blooms taxonomy. They can be said to be at knowledge and comprehension levels. This is due to the fact that most of the observed activities were procedural type of practical work and they did not challenge learners to think about the purpose of the experiment or the sequence of the steps involved. For example, most of the qualitative analysis practical activities had the following objectives*;* (a) define ions (b) state the ions present in the solution (c) Name the sample given.

Learners were expected to follow the instructions religiously so that they could remember the activities later. This is due to the fact that a deductive approach was mostly employed by the teachers. In a deductive classroom the role of the teacher is to conduct lessons by introducing concepts, explaining them to learners and thereafter expecting the learners to complete the tasks. On the other hand some of the activities did not even have stated objectives to clearly show what the practical activity designer (teacher) wanted to be achieved by the end of the day. It can be said that the observed teachers' understanding was that as long as learners manipulated the materials and pieces of apparatus, then the practical activities were successful, because they are likely to do the same during the final chemistry practical examination. It can further be noted that those who designed worksheets or modified past examination practical papers activities for their lessons made an effort to state the objectives for their practical activities.

Hodson (1991:176) argues that: "as practised in many schools practical work is ill-conceived, confused and unproductive. For many learners what goes on in the laboratory contributes little to their learning of science". Hodson's argument implies that the way practical work is conducted in most schools does not really help learners to construct knowledge and understanding of the science concepts. It can be claimed that the nature of these ill-conceived practical activities is similar to most of those that were observed in this study. This was so because most of the practical activities did not have objectives stated of what the teacher wanted the learners to learn. It was also a common practice that mostly the focus was on learners being able to manipulate the pieces of apparatus. This point is further emphasised by Millar (2008) who points out that teachers need to critically examine the objectives of the practical tasks that they give to the learners. They also need to be aware of the cognitive benefits as well as challenges for their learners. This implies that they must be clearer than they are about the learning objectives of the practical activities that they use.

It is also clear from the findings that most of the practical activities observed were procedural. Teachers gave learners an outline of steps to follow, learners did not have an opportunity to come up with alternative procedures as a result restricting their creativity. Ituma, Twoli and Khatete (2015) points out that practical work as practiced in secondary schools has been a cookbook trend where instructions are carried out like a recipe, this reduces meaningful learning. Learners do not use scientific ideas to guide their actions during the practical activity and they barely reflect on the data collected. This is a clear indication that the nature of practical work done mostly in secondary schools does not promote learners conceptual understanding.

On the other hand Olufsen et al (2015) classifies practical as; teacher demonstrations, cookbook/recipe style experiments and open ended/inquiry experiments. This classification of practical activities is similar to that which was used in this study such as; procedural, illustrative and investigative. Among the three categories procedural/recipe style is the most frequently used in secondary schools. Though popularly used, procedural practical activities are said to be an ineffective way to learn science concepts as observed and might give a wrong picture of how knowledge is developed in science (Gunstone and Champagne, 1990; Millar, 2004).

In the practical lessons observed most of the time was spent on following the steps and doing the practicalities of the activity rather than focusing on how to enhance learner’s conceptual understanding. These practical activities were not informed by the basic ideas of science as inquiry. Learners were unable to formulate sound explanations and connect the explanations to scientific knowledge. Sharpe (2012) expresses a similar view that a lot of time in practical work lessons is spent on setting up and organising equipment as well as drawing results tables. Though worksheets had questions that learners were expected to answer after the activity, they did not provide an opportunity for the teacher to spontaneously ask questions that arose during the practical activities so as to direct learners thinking.

It can certainly be pointed out that teachers did not take advantage of the practical activities to access learners' ideas and channel them towards constructing knowledge and understanding from the data they collected. In most cases the questions asked did not encourage learners to think critically about the chemistry concepts. Out of the 12 practical activities observed, only 1 practical activity on preparation of soluble salts was investigative. Teacher C provided the various materials for the learners but did not give a layout of steps for them to follow. The worksheet consisted of a mix of questions that somehow helped the learners to grasp the concepts at hand, for example; (a) describe the preparation of copper (II) nitrate salt (b) state the reagents needed to prepare the given salt. At least learners came up with their own procedures and they worked towards solving a problem with less guidance from the teacher. The underlying short-coming is that everything teachers did were tailored to prepare learners for the examination. It was not so much on helping learners to have a conceptual understanding of chemistry concepts. Learners did not benefit so much from the activities. Chiappetta and Koballa (2010) contends that learners following strictly set procedures to arrive at a predetermined outcome is somehow limiting and does not lead to meaningful learning in science. Similarly, Emereole (2009) argues that it is not enough to verify science laws and principles by simply following the procedures. It is important therefore, to provide conditions and tasks that enable learners to understand the scientific concepts whether they are theoretical or practical.

The use of practical work is underpinned by the core constructs of science as inquiry and constructivism theory. Scientific inquiry from the classroom context is described as a set of abilities and understandings that include asking scientifically oriented questions, giving priorities to evidence in responding to questions, formulating explanations and connecting to scientific knowledge and justifying explanations (NRC, 2000). On the other hand constructivist theory of learning emphasises the active role of the learners in the construction of their own knowledge (Schunk, 2012). Therefore, teachers' competencies in the design and delivery of chemistry practical activities should be informed by science as inquiry and constructivism through; properly planned and properly executed chemistry practical activities not by the passing of examination requirements. This is important in helping learners to construct their own knowledge through hands-on activities.

Additionally, learners are helped to give priority to generation of evidence for scientifically oriented questions and developing the ability to formulate scientifically sound explanations of their observations. But this was not the case in the observed practical activities. The activities were used mostly for verification and confirmation of certain ideas taught during the theory lessons not for the construction of knowledge. Learners were not so much helped by the teachers to give scientific sound explanations from the observations made and the data they collected.

The study further revealed that the practical activities were used not only to expose learners to pieces of apparatus but also to procedures that are likely to be followed during examinations. The practical activities done were not consolidated in laboratory reports but simply functioned as an enjoyable component to a set of general questions on the content covered in the theory lessons. This was the case because; teachers lacked the correct concept of the nature of science, they did not actually understand the role of practical activities as evidenced by some of the comments made as reasons for doing practical work; “learners learnt how to handle the apparatus they were using…” or their specific content knowledge might be weak. McConnell, Parker and Eberhardt (2017) narrate that one of the characteristics of effective science teachers is a deep understanding of science concepts. The ability to explain, apply concepts is critical in designing, delivering and assessing instruction. Hodson (1996) adds that, in order to help learners develop scientific understanding practical activities should be more demanding cognitively, rigorously designed and well prepared.

The findings of this study seem to corroborate with that of Millar (2008) and Jimmi (2014) that teacher’s competency in designing practical activities is at low level. It is important to note that the effectiveness of practical science depends on the ability of a teacher to design and plan the objectives of the task clearly. Objectives set the pace for the learners’ activities, the role of the teacher and most importantly the design of the practical work.

5.3 The Range of Science Process skills developed through teacher designed practical activities

The study revealed that the practical activities in the lessons observed were only designed from three areas and these were; qualitative analysis (identification of ions), volumetric analysis (titration) and preparation of soluble salts. In the actual sense the syllabi and schemes of work showed that there were more than 10 areas where practical activities would have been drawn from. Due to the fact that most of the practical activities were procedural only few science process skills were developed. It also suffices to mention that most of these science process skills were basic because the objectives of the activities did not focus on higher level of cognitive domain.

Additionally, the questions asked did not encourage learners to think critically so as to use and develop a wider range of science process skills. These practical activities involved the use and the development of the following science process skills; observation, communication, classification, measuring, experimenting, using numbers and interpreting data. These practical activities did not develop the same science process skills. Qualitative analysis practical activities developed; observation, classification, communication and experimenting. Volumetric analysis practical activities developed; observation, communication, measuring, interpreting data, using numbers and experimenting while preparation of soluble salts developed; observation, classification, communication, interpreting data and experimenting.

Observation was being used by the learners during the activities. However, the teachers did not exploit learner's observations so that they are able to construct knowledge and derive meaning from their observations. The observations were merely focused on the colour change. For example, during qualitative analysis practical activities, observation was used to denote substances as either positively charged ions (cations) or negatively charged ions (anions). Mwangi (2016) expresses concern that a practical task designed to enable learners to observe an object or phenomena can easily become rather dull and uninspiring, unless it is a striking and memorable one. Relating to this concern, learners were in a position to notice details about the phenomena but they were not so much helped in thinking about the data obtained from observations and its relationships.

Classification was mostly used in qualitative analysis practical activities. It was basically involved in grouping substances as either positively charged particles (cations) or negatively charged particles (anions) based on colour change patterns. But the process skill was not used to detect the relationships so as to identify similarities and differences in phenomena. Classifying involves organising observations, therefore teachers ought to design practical activities in such a manner that allow learners to make observations and classify objects based on similarities, differences and relationships.

Communication was also developed during the practical activities. Though this was the case, mostly it was more of agreeing what colour to record. It is important for learners to develop this science process skill because it helps in the presentation of data into some form so that others can understand. Data can be communicated using graphs, symbols, tables, charts and diagrams.

Measuring was also used in a set of volumetric analysis practical activities. Learners did transfer an exact amount of the base into a conical flask for titration. It was observed that learners were measuring 25 ml of the base using a measuring cylinder that was in place of a pipette. On the contrary, the teachers did not emphasise the need for learners to take the readings with units as calibrated on the instruments so as to foster scientific measuring. Miles (2010) points out that measuring is at the heart of chemistry learning because it enables learners to perform chemical reactions and perform their findings in a standard and systematic manner. It provides an opportunity for learners to express their observations in quantitative terms leading to precision and accuracy in the description of phenomena. Because the practical activity was procedural in nature, learners could not even observe and quantify the temperature change by measuring the temperature to get the concept of exothermic reaction.

Experimenting, this process skill was used in all the 12 practical lessons observed. This is the case because the practical lessons were being referred to as experiments. Although experimenting as a process skill is mainly involved in hands-on activities, there was no problem identification, hypothesis formulation rather it was mostly used as a means for observations and manipulation of apparatus. Using numbers was used or developed during the volumetric analysis activities because there was an opportunity for learners to take the readings on the burette and later use them during interpretation of data. Interpreting data, this was developed through the following guiding questions on the worksheet which culminated into learners doing some calculations. For example; (a) "find the volume of hydrochloric acid (HCl) which reacts with 25ml of sodium hydroxide (NaOH)". (b) Calculate the number of moles of the acid that reacted with NaOH". There were no further opportunities for learners to attach meaning to these calculations. Interpreting data normally comes after data gathering through observations, classifying and measurements. They did not link their interpretation to the observations and measurements taken. Generally, teachers did not ask questions that would have focused and engaged learners in the use of other process skills as they collected, analysed and constructed meaning of the data collected. Therefore, learners did not transform data so as to draw conclusions.

It is clear from the study that the practical activities observed mostly developed basic science process skills in one way or the other. Though basic science process skills are core to the process of science, integrated science process skills are also crucial to the learning of chemistry as a science. Because they enable learners to think scientifically and critically by resolving their cognitive conflicts as they make predictions and state their inferences. When teachers were asked how they enhanced the development of science process skills, the common response was "by doing hands-on activities, learners will learn the skill of how to handle the apparatus and make observations". This may imply that teachers did not fully understand the role of practical activities in the development of science process skills consequently they lacked the knowledge and ability of developing a wider range of science process skills through practical activities.

To some extent the findings of this study that practical activities designed by teachers were procedural hence they fostered the development of basic science process skills are in line with the findings reported by Mbewe, Mumba and Chabalengula (2010) that teachers had difficulties in defining and explaining certain science process skills such as inferring, formulating hypothesis, defining operationally, interpreting data, predicting, controlling variables and using space/time relations. It can be assumed that the absence of opportunities in the practical activities observed in this study to foster integrated science process skills might be attributed to lack of a clear understanding of these skills by the teachers. This claim is supported by the findings reported by Emereole (2009) that teachers did not have sufficient conceptual understanding of science process skills to help their learners develop and understand science process skills in a meaningful way.

5.4 Level of creativity in teacher designed chemistry practical activities

Creativity in the design and delivery of chemistry practical activities was established by focusing on the originality of the tasks and the level of improvisation in these practical activities. The results of the study revealed that most of the practical activities observed were either just lifted past examination practical activities or modified. This implies that there was no originality in the practical activities given to learners by teachers. School science has been described to offer a backward view of science and its processes (Osborne, Simon and Collins, 2003). However, what appeals to and excites learners are the technological advances of the future offered by science. Therefore, in order to focus on learner's interest school science should be should be taught creatively. In view of this, there is need for high levels of learner involvement in practical activities, use of variety practical activities and teaching strategies and learning strategies (Osborne, Simon and Collins, 2003; Millar, 2004).

The study further showed that there was no variety in the activities observed. Only three categories of activities were conducted namely; volumetric analysis, qualitative analysis and preparation of salts. This lack of variety in the practical activities designed by the teachers point to lack of innovation and creativity. For example, statements like "we only focus on qualitative and volumetric analysis practical activities because they are the ones that come in the exam", are a clear indication of teachers lack of creativity in the design of practical activities. This implies that though teachers may be knowledgeable about their subject, they seem to be failing to achieve the primary task of establishing a range of varied learning opportunities for learners.   Practical work should provide opportunities for learners and the teacher to engage in a discussion of the observations and measurements made. However, Millar 2004:16 points out that:

> Teachers interpret and operationalize the use of observations and measurements in so many ways for the purposes of national examinations…using one of a very small set of practical tasks from year to year, chosen to make it as easy as possible for their students…without being told explicitly what to do students are coached and corralled through these activities so that they obtain as high marks as possible.

This is also true for the practical activities that were observed in this study. The study revealed that one of the reasons for doing practical activities was to prepare learners for the examination. For instance Teacher E stated that “believe you me even if I have not seen the advance copy for this year I know that titration is there, so I will try to focus on that”. This entails that practical activities are likely to be designed in a manner that simply exposes learners to procedures and pieces of apparatus. Learners will be unable to build a bridge between what they see, handle and the scientific ideas that account for their observations (Machina, 2012).

Abrahams and Millar (2008) points out that it is unlikely that a learner would grasp a new scientific concept or understand a theory as a result of any single practical task no matter how well designed. It is clear from this view that learners need to be exposed to a number of varied practical activities. This is also echoed by Mwangi

(2016) that learners acquire deeper understanding of a set of ideas in a gradual process hence the need for frequent and varied practical activities.

It suffices to mention that there is a link between teacher's creativity, the nature of practical activities designed and the science process skills that can be developed from these practical activities. It is clear from the findings of the study that the teachers lacked creativity in the way they designed the practical activities for their lessons. Due to this fact science process skills were not developed in a manner that would lead to understanding of concepts and ideas. This view is somehow similar to that expressed by Miles (2010) who said that learners are likely to develop a positive attitude towards science process skills if they have had a hands-on inquiry experience. Most of the practical activities observed in this study were characterised by learners strictly following given procedures as a result they were more hands-on engaged rather than both hands-on and minds-on.This means that learners focused on the procedures and manipulation of pieces of apparatus rather than thinking about the procedures and ideas involved in the practical activities. Henceforth, the data they collected during these practical activities was not consistent with the intended conclusion. This resonates with the findings by Jimmi (2014) that in a situation where learners collected data that was good enough for the purpose at hand, they were unable to draw the intended conclusion from it.

On the other hand the findings showed that teachers appreciated the importance of improvisation in their chemistry practical lessons. However, they seemed not ready to go a step further in coming up with alternative pieces of apparatus and some chemicals not available in their laboratories. Their improvisation was more inclined to pieces of apparatus as a result it was simply a replacement of a missing piece of apparatus with another which was available not totally coming up with something new that was not available in the laboratory.

5.5 Summary of Discussion

This chapter discussed findings on the nature of practical activities designed and delivered by chemistry teachers, the range of science process skills developed through teacher designed practical activities and the level of creativity in the practical activities designed by teachers. It became apparent that most of the practical activities observed were procedural in nature. These types of practical activities do not provide opportunities for learners to meaningfully understand chemistry concepts. It has also become apparent that teachers need to critically examine the objectives of the practical activities they design for their learners.

Looking at the nature of these practical activities, opportunities for learners to develop a wider range of science process skills were minimal. A few science process skills were developed however learners were unable to create a link between their observations, measurements and conclusions. Additionally, there was lack of variety in the practical activities designed by teachers. The focus was on those activities that frequently come in practical examinations as well as exposing learners to pieces of apparatus at the expense of knowledge and understanding. The next chapter presents conclusions and recommendations.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This chapter sums up the study by first presenting the conclusions of the study and then make recommendations to science teacher educators, ministry of education, chemistry teachers and to future researchers.

6.2 Conclusion

This study was based on a qualitative approach and was intended to provide insight on the nature of practical activities designed and delivered by teachers. The study revealed that most of the practical activities designed by teachers were characterised by: learners following laid down procedures, learners were not given an opportunity to come up with alternative procedures and the objectives were mostly at low levels of cognitive domain. Though teachers acknowledged the importance of objectives in the design of their practical activities most of the practical activities observed had no stated objectives to clearly show what the teacher wanted to achieve while those practical activities that had objectives most of them were at knowledge and comprehension cognitive levels. It was also noted that the focus of most of the practical activities was to expose learners to pieces of apparatus, verify and confirm what was discussed during theory lessons. Generally, it can be said that these practical activities are procedural in nature.

The practical activities that were designed and delivered by chemistry teachers came from three topics of the syllabus and these are qualitative analysis, volumetric analysis and preparation of soluble salts. The following range of process skills were developed from the nature of chemistry practical activities designed and delivered by chemistry teachers; observation, classification, communication, measuring, experimenting, interpreting data and using numbers. The practical activities developed mostly basic science process skills, however, teachers did not ask questions to engage learners in constructing meaning out of the data they collected. Though these process skills were observed to be developed, they were not effectively developed as science process skills that could lead learners to construct their own understanding. For instance, measuring was done by merely transferring substances from one piece of apparatus to the other without paying attention to the correct units as calibrated on the instruments. Teachers seemed not to understand the role of practical activities as a result they exhibited insufficient knowledge and ability of helping learners to develop a wider range of science process skills through practical activities.

The observed practical activities lacked originality because chemistry teachers did not design these activities for their lessons but just lifted them from past examination practical papers. There was also no variety in the practical activities given to the learners, this is a clear indication of lack of creativity and innovation in the practical activities designed by chemistry teachers. It is clear from the findings of this study that there are a number of areas that need strengthening in terms of chemistry teachers competencies in the design and delivery of practical activities.

6.3 Recommendations

In light of the findings of this study, below are the recommendations made to some of the stakeholders in the provision of education in Zambia:

1. There is need for science teacher educators to strengthen their education programs in terms of student exposure to practical activities especially investigative ones. This is in order to adequately equip science student teachers with knowledge and provide opportunities to expand their understanding of science process skills.

2. The ministry of education through the directorate of curriculum and standards should monitor closely the implementation of both science (5124) and pure chemistry (5070) syllabi. They should ensure that most of the practical activities prescribed for the various topics if not all are done creatively and innovatively.

3. Science standards officers should organise workshops and continuous professional development (CPDs) for chemistry teachers to train them on how to design practical activities.

4. Chemistry teachers should design practical activities that provide opportunities for learners to understand chemistry concepts and develop science process skills.

5. There is need for chemistry teachers to form communities of practice so as to share ideas on practical activity design and material improvisation.

6. Heads of science department should organise continuous professional development (CPDs) for chemistry teachers to share knowledge on practical activity designing for various topics in the syllabi.

For Future Research

i. There is need to extend this study to a larger sample of participants.

ii. A longitudinal study should be conducted so as to get a clearer picture of the nature of chemistry practical activities designed and delivered by teachers.

iii. Future research should endeavour to extend the scope of this study using mixed method approach. Both quantitative and qualitative data must be collected; quantitative data should involve the use of a questionnaire on teachers' competencies in the design and delivery of chemistry practical work.

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APPENDICES

APPENDIX A: TIME TABLE

DATE	ACTIVITIES	COMMENTS

28/07/17	PREPARATION FOR FIELD WORK • Submission of proposal • Data collection instruments completed.	
30/08/17	• Submission for ethical clearance	
30/09/17	DATA COLLECTION • Lesson observation • Document analysis	
30/10/17	• Focus group discussions • Interviews	
30/11/17	DATA ANALYSIS BEGINS • Data sorting • Data cleaning	
28/02/18	REPORT WRITING • Submit revised chapters (1,2&3)	
30/04/18	PRESENTATION OF FINDINGS • Seminar presentations	
30/07/18	SUBMISSION FOR EXAMINATION	

DATA COLLECTION INSTRUMENTS

APPENDIX B: LESSON OBSERVATION SCHEDULE

1. What is the nature of Chemistry Practical Activities designed and delivered by Chemistry Teachers?

Descriptors	Observed			
What is title of the practical activity? Title:____				
Are the objectives clear? Objectives:____ ____				
Are the objectives achievable?				
Is the practical activity designed to illustrate a concept or principle?				
Pupils working towards confirming an idea				
Pupils doing a specific task that is easily organised by the teacher				
Is the task structured or unstructured?				
Is the practical activity procedural?				
Are pupils following a list of steps provided by the teacher?				
Are pupils allowed to come up with an alternative method?				
Is the practical activity investigative?				
Did teacher present a scientific problem to learners?				
Are pupils openly using various procedures to conduct the activity?				
Are pupils working towards solving a problem?				
Is sufficient time allocated to the practical activity?				
Does the activity help learners link practical to real life situations?				

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2. Science Process Skills are developed through Chemistry Teachers designed Practical Activities

Descriptors	Observed			
Are the learners making observations?				
Are they identifying patterns in objects?				
Are the learners quantifying observations and recording?				
Are the learners communicating through various ways?				
Are the learners encouraged to make predictions based on observations and measurements?				
Are they drawing tentative conclusions from observations & measurements?				
Are they recording and manipulating numbers?				
Are they controlling variables?				
Are the learners interpreting the data obtained?				
Are the learners formulating hypotheses?				
Are they defining terms based on what is done and observed?				
Are they experimenting?				

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5. What is the Level of Creativity in teacher designed Chemistry Practical Activities? = Idea+ Action

Descriptors	Observed			
Is the task original?				
Is the task inspiring and motivating?				
What phenomenon is being explored?				
Are they testing a theory? or interrogating it?				
Are they interrogating a theory, principle or law?				
Are the apparatus needed for the task appropriate?				
List of apparatus involved____ ____				
What is the level of improvisation in the apparatus used?				
Do learners have an opportunity to evaluate what they are doing?				

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6. Actual Classroom Actions

Descriptors	Observed			
Did the teacher clearly explain the procedure to the learners?				
Did the teacher highlight safety rules?				
Are they working in small groups?				
Are learners working individually?				
Handling apparatus appropriately?				
What conclusions are being drawn from the given task?				
What conclusions does the teacher draw from the practical activity?				
Are the objectives of the practical being achieved?				
What implications have the teachers/leaners have on development of process skills?				

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APPENDIX C: DOCUMENT ANLYSIS SCHEDULE

1. SYLLABI

a) Which part of the syllabus is the practical activity coming from?
b) Are the objectives measurable and attainable?
c) What other practical activities are suggested for the topic?
d) Why has the teacher made that choice?

2. SCHEMES OF WORK

a) Is practical one of the teaching learning strategies?
b) How frequent is practical work appearing in the scheme?
c) How varied are the practical activities in the scheme?
d) Are the suitable apparatus indicated?

3. LESSON PLAN

a) Is practical work used to introduce the lesson?
b) Is the lesson completely practical or …?
c) The time allocated to the practical
d) At what stage of the lesson did the teacher plan for the practical activities?
e) What type of practical activity is it?
f) Is the practical work sheet part of the lesson plan?

4. PRACTICAL ACTIVITY WORK SHEET

a) The title of the activity clearly stated
b) The aim of the activity clearly started
c) Safety rules clearly stated
d) All the required materials clearly listed
e) Any improvisation in terms of materials and apparatus required
f) Where the instructions clearly stated or the learners were required to state how they carried out the investigation?
g) Did it guide the learners on how to record the data and their observations
h) Data analysis questions
i) Did they generate a table of results?
j) Did they draw graphs?

APPENDIX D: SEMI- STRUCTURED INTERVIEW SCHEDULE

1. What is this practical activity intending to achieve?..

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2. What are learners going to learn from this activity? Why?....................................

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3. What is your focus when you prepare practical work for the learners?

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4. How do you enhance the development of science process skills in your practical lessons?...

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5. What do you take into account when you are designing a practical activity?

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APPENDIX E: FOCUS GROUP DISCUSSION GUIDE

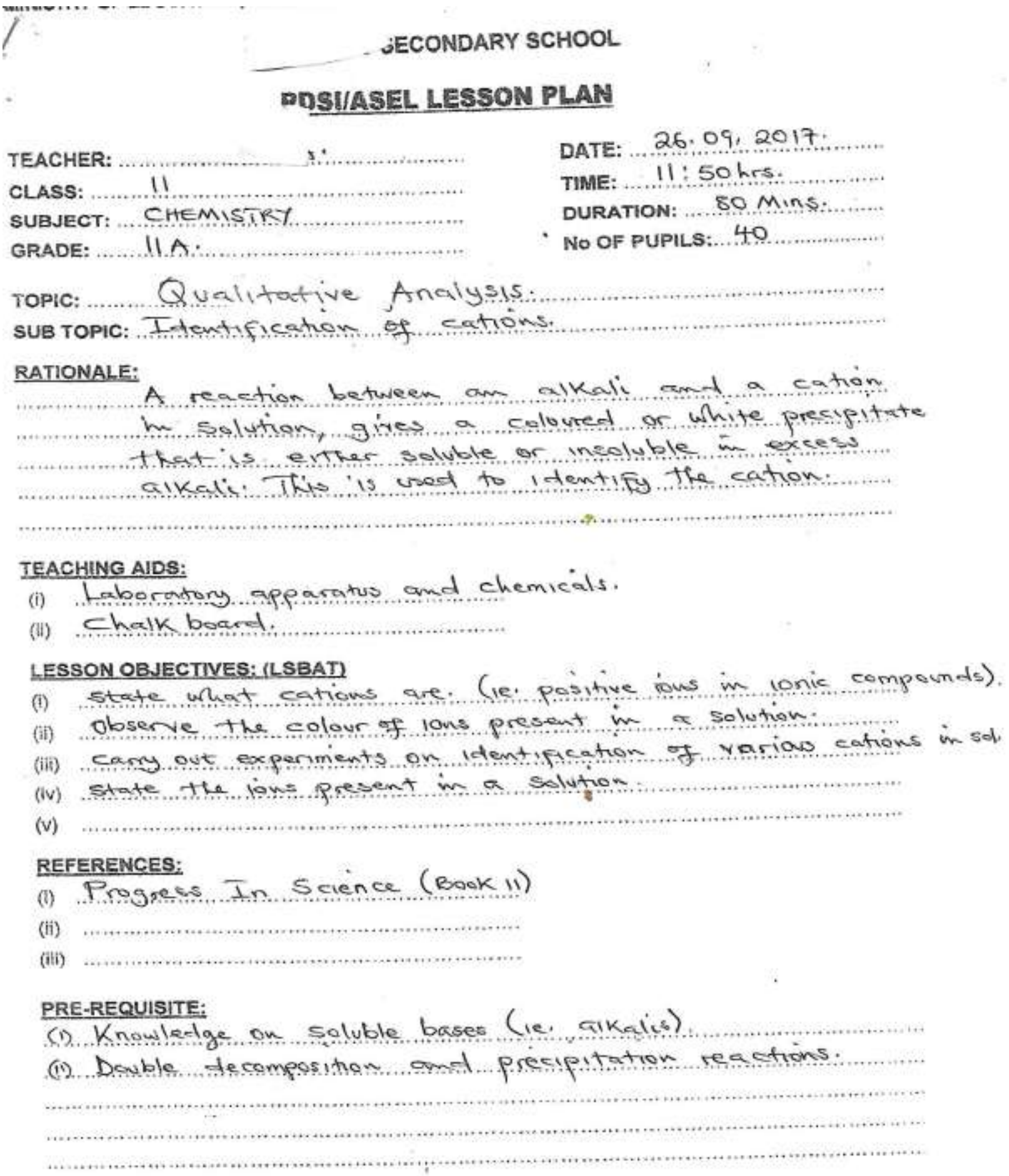
1. What is the role of practical activities in your chemistry lesson?
2. Do you always prepare a practical work sheet for your Chemistry lessons?
3. Does your practical activity design guide learners to link science concepts to real life situations?
4. What is the best way of delivering practical activities in your chemistry lesson?
5. What are some of the challenges you encounter during the delivery of practical activities in classrooms?
6. What type of practical activities do you frequently prepare for your learners?

APPENDIX F

Grade 12 Performances in Chemistry (5070) and Science (5124) in Zambia from 2006 to 2010.

			YEARS																
			2006			2007			2008			2009			2010			AV PASS%	
PROVINCE	SCHOOL	SUBJECT	SAT	PASS	**PASS%**	SAT	PASS	**PASS%**	SAT	PASS	**PASS%**	SAT	PASS	**PASS%**	SAT	PASS	**PASS%**	**5070**	**SCI(2154)**
NORTHERN	MUNGWI TECH	CHEM(5070)	216	31	**14.2**	124	19	**15.3**	138	41	**29.7**	125	29	**23.2**	160	30	**19**	**20.24**	
		SCIE(5124)	81	13	**16**	173	27	**15.6**	184	30	**16.3**	155	27	**17.4**	233	32	**14**		**15.8**
MUCHINGA	KENNETH K	CHEM(5070)	12	O	**0**	5	1	**20**	1	1	**100**	8	2	**25**	1	1	**100**	**49**	
		SCIE(5124)	178	27	**15**	161	33	**20.3**	110	17	**15**	155	31	**20**	301	63	**21**		**18.3**
LUAPULA	MANSA SEC	CHEM(5070)	9	3	**33.3**	3	1	**33**	22	16	**72.2**	30	3	**9**	8	4	**50**	**39.5**	
		SCIE(5124)	247	38	**15.4**	281	27	**13.4**	221	25	**11.3**	248	94	**38**	610	31	**5.1**		**16.6**
COPPERBELT	KITWE BOYS	CHEM(5070)	40	10	**25**	36	18	**50**	24	9	**37.5**	32	9	**28.1**	12	8	**67**	**41.46**	
		SCIE(5124)	400	210	**52.5**	323	179	**55.4**	391	222	**56.8**	316	164	**52**	564	233	**41**		**51.6**
N/WESTERN	SOLWEZI TECH	CHEM(5070)	55	17	**31**	84	23	**27.4**	70	28	**40**	90	15	**16.7**	123	17	**14**	**25.78**	
		SCIE(5124)	291	84	**28.9**	293	48	**16.4**	282	71	**25.2**	259	33	**12.7**	414	54	**13**		**19.2**
CENTRAL	BWACHA SEC	CHEM(5070)	7	1	**16**	7	3	**42.8**	3	1	**33.3**	7	3	**42.8**	2	0	**0**	**26.98**	
		SCIE(5124)	255	52	**20**	255	55	**21.6**	325	41	**12.6**	276	82	**29.7**	414	94	**23**		**21.3**
LUSAKA	MUNALI SEC	CHEM(5070)	121	68	**56.2**	91	40	**44**	79	31	**39.2**	80	38	**47.5**	121	73	**60**	**49.44**	
		SCIE(5124)	296	172	**58**	519	167	**32.2**	274	64	**23.4**	295	120	**41**	577	232	**40**		**39**
EASTERN	CHIPATA SEC	CHEM(5070)	22	8	**36.4**	12	11	**91.7**	20	5	**25**	25	11	**44**	20	6	**30**	**45.42**	
		SCIE(5124)	233	48	**20.6**	249	52	**20.8**	291	37	**12.7**	227	39	**17.2**	505	62	**12**		**16.7**
WESTERN	KAOMA SEC	CHEM(5070)	43	7	**16.3**	41	4	**9.8**	41	10	**24.4**	32	16	**50**	31	11	**36**	**27.2**	
		SCIE(5124)	121	19	**15.7**	152	10	**6.6**	142	17	**12**	216	18	**8.3**	159	25	**16**		**11.7**
SOUTHERN	LINDA SEC	CHEM(5070)	83	9	**10.8**	42	5	**11.9**	92	8	**8.7**	105	4	**3.8**	115	11	**9.6**	**8.96**	
		SCIE(5124)	214	129	**60.3**	262	28	**10.8**	266	31	**11.7**	219	14	**6.4**	548	31	**5.7**		**19**
		OVERALL																**33.4**	**22.9**

APPENDIX G: SAMPLE OF A LESSON PLAN



SECONDARY SCHOOL

PDSI/ASEL LESSON PLAN

TEACHER:
CLASS: 11
SUBJECT: CHEMISTRY
GRADE: 11A.

DATE: 26. 09. 2017.
TIME: 11:50hrs.
DURATION: 80 Mins.
No OF PUPILS: 40

TOPIC: Qualitative Analysis.
SUB TOPIC: Identification of cations.

RATIONALE:

A reaction between an alkali and a cation in solution, gives a coloured or white precipitate that is either soluble or insoluble in excess alkali. This is used to identify the cation.

TEACHING AIDS:

(i) Laboratory apparatus and chemicals.
(ii) Chalk board.

LESSON OBJECTIVES: (LSBAT)

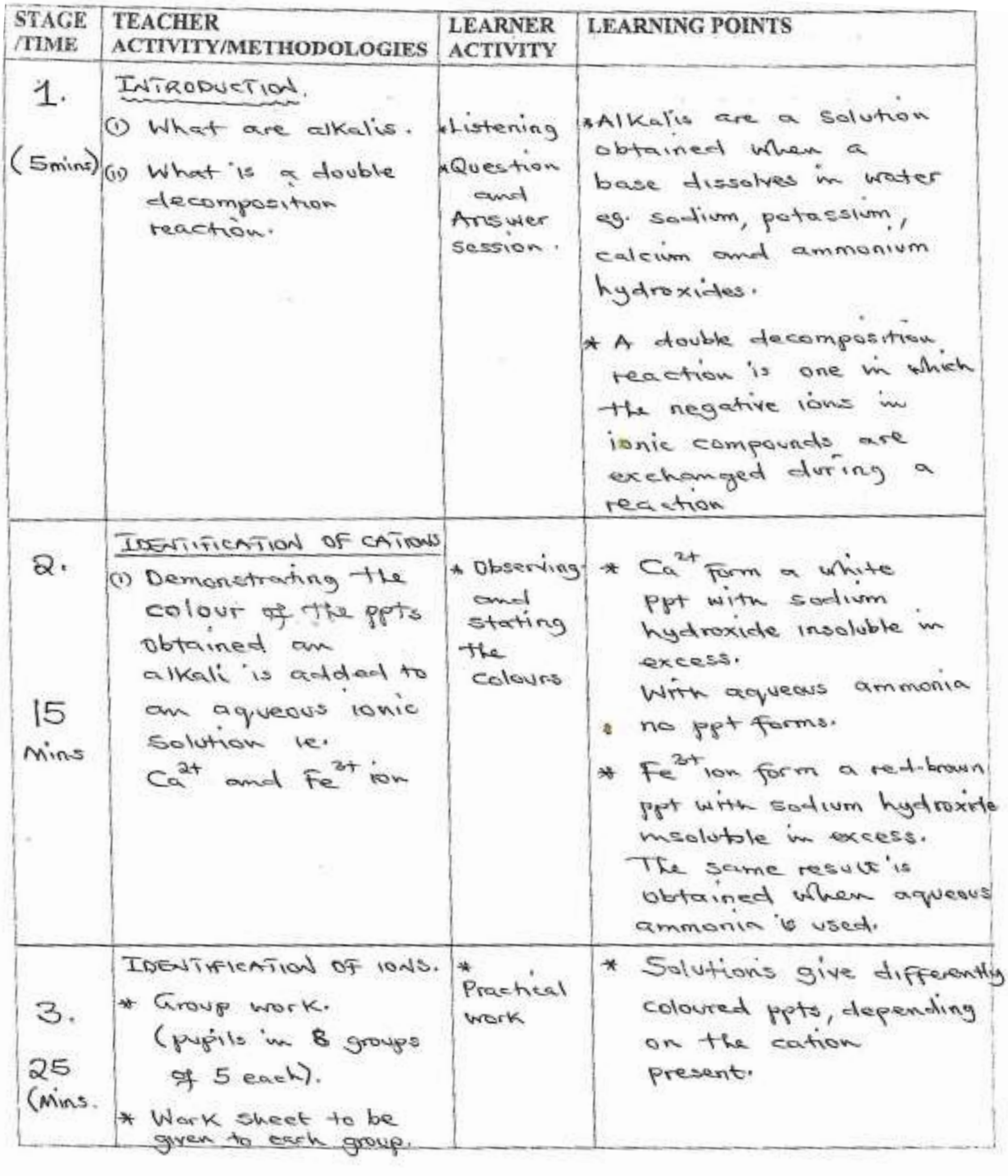
(i) state what cations are. (ie. positive ions in ionic compounds).
(ii) observe the colour of ions present in a solution.
(iii) carry out experiments on identification of various cations in sol
(iv) state the ions present in a solution.
(v)

REFERENCES:

(i) Progress In Science (Book 11)
(ii)
(iii)

PRE-REQUISITE:

(i) Knowledge on soluble bases (ie. alkalis)
(ii) Double decomposition and precipitation reactions.



STAGE /TIME	TEACHER ACTIVITY/METHODOLOGIES	LEARNER ACTIVITY	LEARNING POINTS
1. (5mins)	INTRODUCTION. (i) What are alkalis. (ii) What is a double decomposition reaction.	*Listening *Question and Answer session.	*Alkalis are a solution obtained when a base dissolves in water eg. sodium, potassium, calcium and ammonium hydroxides. * A double decomposition reaction is one in which the negative ions in ionic compounds are exchanged during a reaction
2. 15 Mins	IDENTIFICATION OF CATIONS (i) Demonstrating the colour of the ppts obtained an alkali is added to an aqueous ionic solution ie. Ca^{2+} and Fe^{3+} ion	* Observing and stating the colours	* Ca^{2+} form a white ppt with sodium hydroxide insoluble in excess. With aqueous ammonia no ppt forms. * Fe^{3+} ion form a red-brown ppt with sodium hydroxide insolutble in excess. The same result is obtained when aqueous ammonia is used.
3. 25 (Mins.	IDENTIFICATION OF IONS. * Group work. (pupils in 8 groups of 5 each). * Work sheet to be given to each group.	* Practical work	* Solutions give differently coloured ppts, depending on the cation present.

SUMMARY: (CONCLUSION)

(i) An alkali and aqueous cation compound reaction forms a precipitate used to identify the ion present.

(ii) The colour of the ppt formed, gives the identity of the cation present.

LEARNING EVALUATION (CLASS EXERCISE)

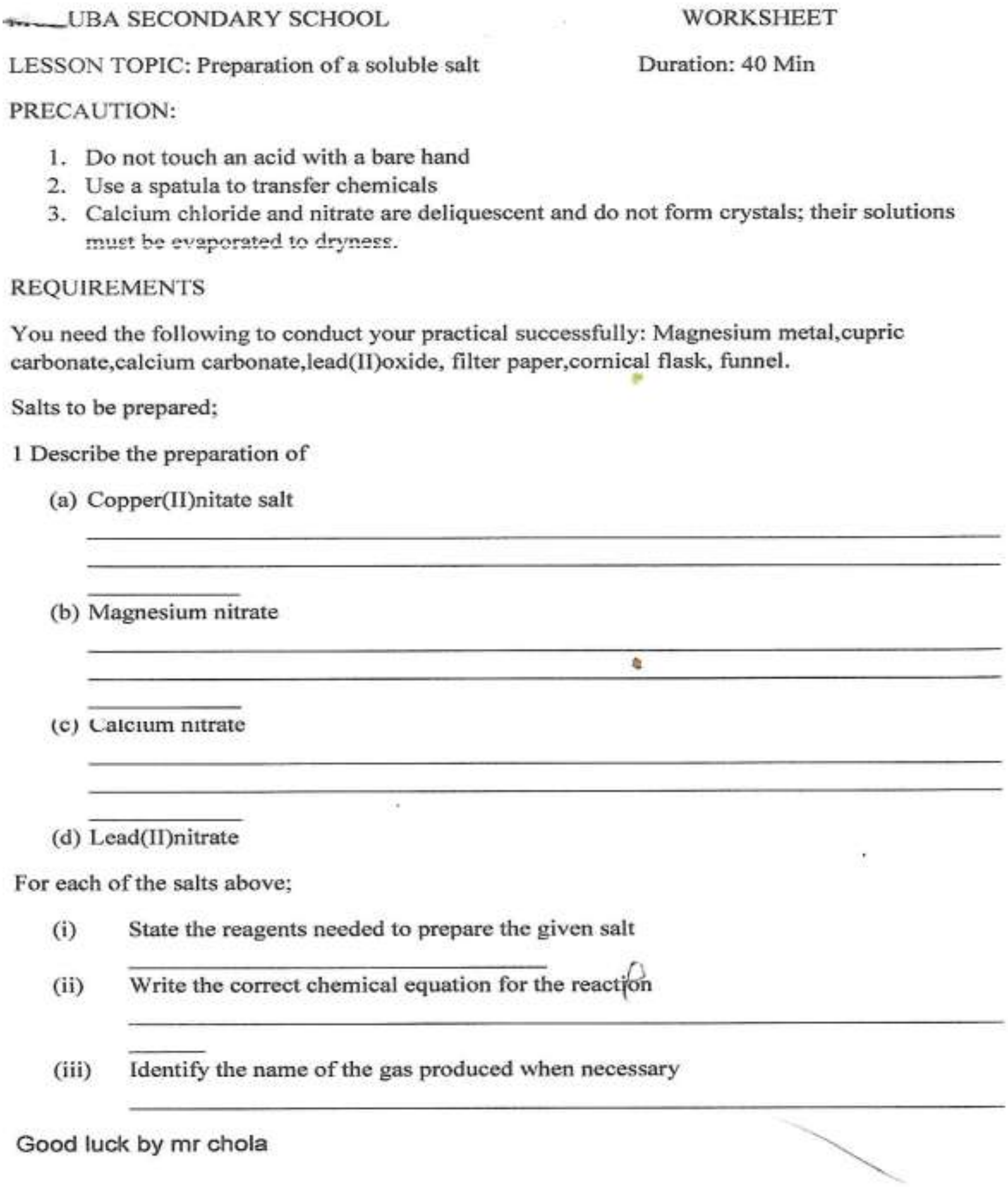
Question and Answer session using the qualitative analysis data sheet to identify the various ions present in a stated solution.

HOME WORK (FOLLOW UP EXERCISE)

N/A.

TEACHER/ LESSON EVALUATION:

APPENDIX H: SAMPLE OF WORKSHEET



[redacted]UBA SECONDARY SCHOOL WORKSHEET

LESSON TOPIC: Preparation of a soluble salt Duration: 40 Min

PRECAUTION:

1. Do not touch an acid with a bare hand
2. Use a spatula to transfer chemicals
3. Calcium chloride and nitrate are deliquescent and do not form crystals; their solutions must be evaporated to dryness.

REQUIREMENTS

You need the following to conduct your practical successfully: Magnesium metal,cupric carbonate,calcium carbonate,lead(II)oxide, filter paper,cornical flask, funnel.

Salts to be prepared;

1 Describe the preparation of

(a) Copper(II)nitate salt

(b) Magnesium nitrate

(c) Calcium nitrate

(d) Lead(II)nitrate

For each of the salts above;

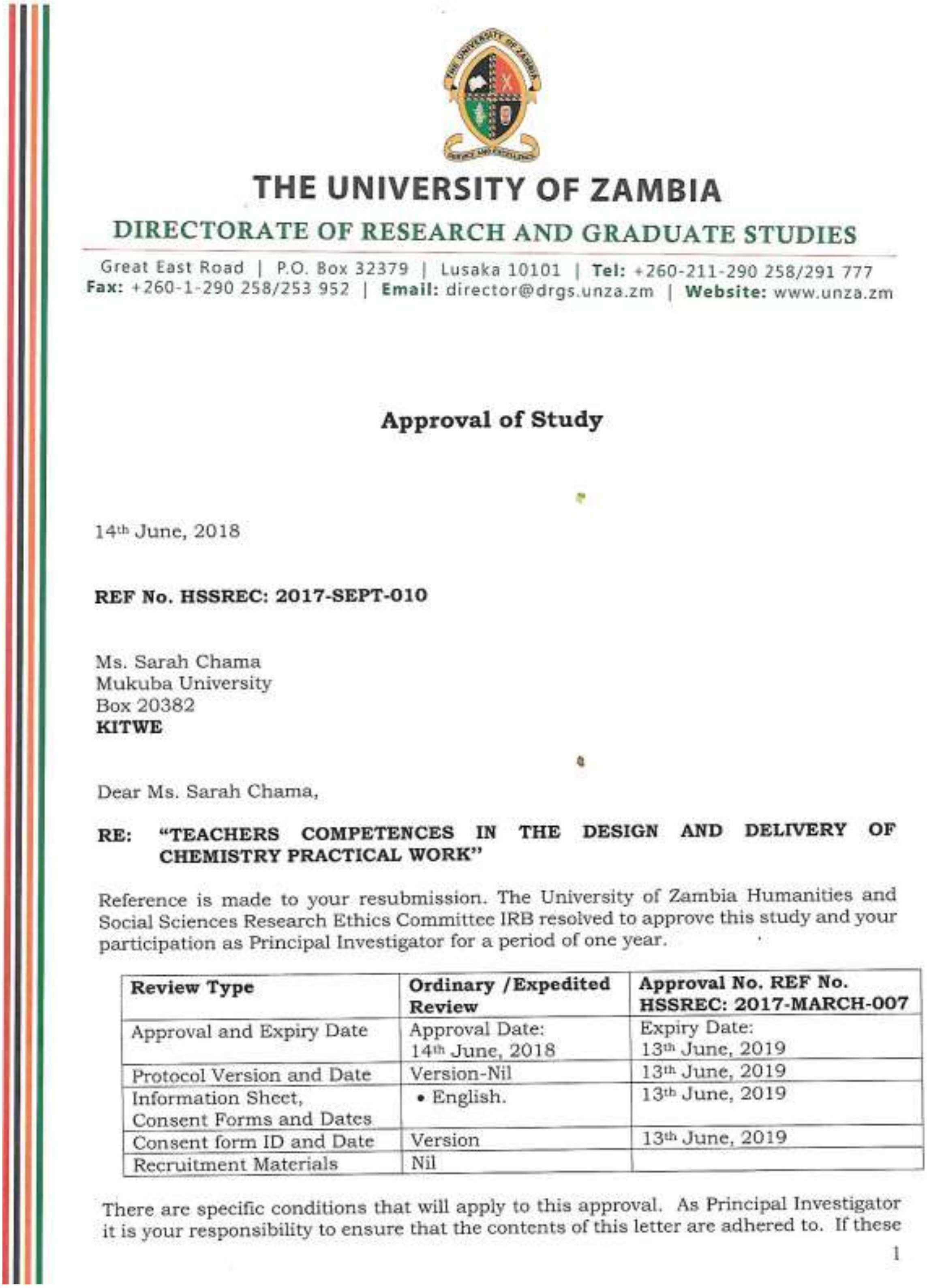
(i) State the reagents needed to prepare the given salt

(ii) Write the correct chemical equation for the reaction

(iii) Identify the name of the gas produced when necessary

Good luck by mr chola

APPENDIX I: ETHICAL CLEARANCE



THE UNIVERSITY OF ZAMBIA
DIRECTORATE OF RESEARCH AND GRADUATE STUDIES
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Approval of Study

14th June, 2018

REF No. HSSREC: 2017-SEPT-010

Ms. Sarah Chama
Mukuba University
Box 20382
KITWE

Dear Ms. Sarah Chama,

RE: "TEACHERS COMPETENCES IN THE DESIGN AND DELIVERY OF CHEMISTRY PRACTICAL WORK"

Reference is made to your resubmission. The University of Zambia Humanities and Social Sciences Research Ethics Committee IRB resolved to approve this study and your participation as Principal Investigator for a period of one year.

Review Type	**Ordinary /Expedited Review**	**Approval No. REF No. HSSREC: 2017-MARCH-007**
Approval and Expiry Date	Approval Date: 14th June, 2018	Expiry Date: 13th June, 2019
Protocol Version and Date	Version-Nil	13th June, 2019
Information Sheet, Consent Forms and Dates	• English.	13th June, 2019
Consent form ID and Date	Version	13th June, 2019
Recruitment Materials	Nil	

There are specific conditions that will apply to this approval. As Principal Investigator it is your responsibility to ensure that the contents of this letter are adhered to. If these

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are not adhered to, the approval may be suspended. Should the study be suspended, study sponsors and other regulatory authorities will be informed.

Conditions of Approval

- No participant may be involved in any study procedure prior to the study approval or after the expiration date.
- All unanticipated or Serious Adverse Events (SAEs) must be reported to the IRB within 5 days.
- All protocol modifications must be IRB approved by an application for an amendment prior to implementation unless they are intended to reduce risk (but must still be reported for approval). Modifications will include any change of investigator/s or site address or methodology and methods. Many modifications entail minimal risk adjustments to a protocol and/or consent form and can be made on an Expedited basis (via the IRB Chair). Some examples are: format changes, correcting spelling errors, adding key personnel, minor changes to questionnaires, recruiting and changes, and so forth. Other, more substantive changes, especially those that may alter the risk-benefit ratio, may require Full Board review and approval. In all cases, except where noted above regarding subject safety, any changes to any protocol document or procedure must first be approved by the IRB before they can be implemented.
- All protocol deviations must be reported to the IRB within 5 working days.
- All recruitment materials must be approved by the IRB prior to being used.
- Principal investigators are responsible for initiating Continuing Review proceedings. Documents must be received by the IRB at least 30 days before the expiry date. This is for the purpose of facilitating the review process. Any documents received less than 30 days before expiry will be labelled "late submissions" and will incur a penalty.
- Every 6 (six) months a progress report form supplied by The University of Zambia Humanities and Social Sciences Research Ethics Committee IRB must be filled in and submitted to us. There is a penalty of K500.00 for failure to submit the report.
- The University of Zambia Humanities and Social Sciences Research Ethics Committee IRB does not "stamp" approval letters, consent forms or study documents unless requested for in writing. This is because the approval letter clearly indicates the documents approved by the IRB as well as other elements and conditions of approval.

Should you have any questions regarding anything indicated in this letter, please do not hesitate to get in touch with us at the above indicated address.

On behalf of The University of Zambia Humanities and Social Sciences Research Ethics Committee (IRB), we would like to wish you all the success as you carry out your study.

Yours faithfully,

Dr. Jason Mwanza
BA, MSoc, Sc., PhD
CHAIRPERSON
THE UNIVERSITY OF ZAMBIA HUMANITIES AND
SOCIAL SCIENCES RESEARCH ETHICS COMMITTEE IRB

CC Director – DRGS
Assistant Director - DRGS