LEARNERS’ SCIENCE PROCESS SKILLS FOR CHEMISTRY 5124 PRACTICAL ACTIVITIES: A CASE OF SELECTED SECONDARY SCHOOLS OF KITWE DISTRICT

BY

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

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DECLARATION

I, Sunday Ng'andu, 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 Sunday Ng'andu has been approved as partial fulfillment of the requirement for the award of the Degree of Master of Education in Science Education by the University of Zambia.

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ABSTRACT

This study investigated the science process skills (SPS) learners use to solve chemistry 5124 practical activities. The study subsequently sought to: establish learner's views on the use of SPS in chemistry 5124 practical activities, identify SPS learners use to conduct chemistry 5124 practical activities, determine the level to which learners use SPS to conduct chemistry 5124 practical activities, and establish the relationship between learners' views on the use of SPS and the SPS learners use to conduct chemistry 5124 practical activities. The study used a mixed methods approach in a convergent mixed methods design to investigate the issues involved. The study sample consisted of 303 grade 12 learners selected from four secondary schools using systematic sampling technique. Data collection instruments were: learners' questionnaire, focus group discussion guide and observation schedule. Qualitative data were analyzed thematically while quantitative data were analyzed by descriptive and inferential statistics generated using the statistical package for social sciences (SPSS) version 20. Findings indicated that learners were of the view that they used SPS such as observing (82%), measuring (57%), classifying (69%), interpreting (74%), inferring (63%) and communicating (67%) skills, except predicting (64%) to conduct chemistry 5124 practical activities. Findings further revealed that learners failed to use most of the SPS like interpreting (83%), inferring (85%), predicting (69%), and communicating (73%) in actual chemistry practical activities. The study concluded that despite learners being of the view that they used most of SPS, they used observing, measuring and classifying at low level, but did not use interpreting, inferring, predicting, and communicating at the least required level when conducting chemistry practical activities. The study also concluded that there was no relationship between views of learners on the use of SPS and SPS learners used to conduct chemistry practical activities (Chi-square =3.272, df=3, $p=0.351>0.05$). As such the study recommended that teachers should emphasize more on acquisition and enhancement of developed SPS among learners, and should also consider the cognitive development level of learners when designing chemistry 5124 practical activities.

Keywords: Learner, Science process skills, Practical activity.

DEDICATION

This dissertation is dedicated to my brother, Kelvin Ng'andu for his unceasing support during my postgraduate studies. I also wish to dedicate this work to all orphans and vulnerable children who may be struggling in their academics, that they may draw encouragement from this and keep working hard as only the sky is the limit.

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ABBREVIATIONS AND ACRONYMS

AAAS	American Association for Advancement of Science
CDC	Curriculum Development Centre
CPD	Continuing Professional Development
DEBS	District Education Board Secretary
DES	Department of Education and Science
ECZ	Examination Council of Zambia
FGDG	Focus Group Discussion Guide
HOD	Head of Department
LQ	Learner Questionnaire
MESVTEE	Ministry of Education, Science, Vocational Training and Early Education
OS	Observation schedule
SPS	Science Process Skills
SPSAI	Science Process Skills Assessment Instructions
SPSS	Statistical Package for Social Sciences
UNICEF	United Nations Children's Fund
ZATEC	Zambia Teacher Education Course

CHAPTER 1

INTRODUCTION

1.1 Overview

This chapter first presents the background to the study, statement of the problem, purpose of the study, study objectives as well as questions/hypotheses. Next it describes the significance, delimitation and limitation of the study. After that it outlines the theoretical framework, conceptual framework, operation definitions and ethical considerations.

1.2 Background to the study

The importance of science education cannot be over emphasized as it ranges from transmission of knowledge, values, culture, skills and norms among others, to actualizing developmental agendas of given societies and nations at large (Akani, 2015; Padilla, 2004). According to Akani (2015), no nation can progress in terms of development without a correct scientific base. Inarguably science is one of the subjects which are able to unleash the potential of learners to turn into desired responsible and productive citizens. Thus, an enviable education system should embrace science as part of core subjects and endeavor to develop and nurture students' potential through a holistic implementation of the set curriculum. This is why nations across the globe endeavor to provide quality science education as the means to facilitate their national development.

There has been debate in academia as to what constitutes quality education. Such arguments are inevitable owing to the fact that quality and education are complex and multifaceted concepts. According to the United Nations Children's Fund [UNICEF], (2000), quality education is one that focuses on the social, emotional, mental, physical and cognitive development of each learner regardless of gender, race, ethnicity, social economic status, or geographic location. This allows for an understanding of education as a complex system embedded in a political, cultural and economic context. Quality science education should therefore prepare learners holistically for life other than making them pass school tests and examinations. This can be achieved by equipping learners with scientific knowledge, process skills, values and positive learning attitudes. Quality education is delivered by good teachers, enabled by good teaching and learning processes and facilitated by a conducive learning environment. Therefore, the balance among the aforementioned factors ought to be found if provision of quality science education is to be achieved.

Furthermore, research has shown that quality science education is achieved by improved teacher education, school partnerships with science-related organizations, establishment of science centres, improved learning environments, provision of classroom libraries and learning materials, deliberately assisting low-achieving learners, offering science oriented guidance to learners, science being taught in context, use of inquiry teaching approaches and so forth (Forsthuber et al., 2012; Park, 2015; UNICEF, 2000). Some countries across the globe like Japan, United States of America, and Singapore among other developed countries have to a larger extent succeeded in this area. However, many developing countries are still striving with regard to provision of quality science education (Willms, 2000). A few countries in Africa, like Nigeria, South Africa and others seem to be doing better in this area than other countries which are still striving to implement the aforementioned initiatives and strategies.

Zambia has not been an exception in striving to provide quality science education. There have been a number of projects, programs and efforts that have been undertaken in order to improve teaching and learning of science in the country. In an effort to do this, in 2013 this country changed the science 5124 curriculum from content to outcome-based curriculum. According to the Ministry of Education, Science, Vocational Training and Early Education [MESVTEE], (2013), the curriculum change was not only necessitated by the need to provide an education system that would integrate most modern social, economic, technological and political developments but also equip learners with fundamental scientific knowledge, process skills and values that are essential to contribute to the attainment of vision 2030. In addition, the government put measures in place to ensure that the system could provide quality education so as to produce well equipped learners. These include; strengthened continuing professional development (CPD) among teachers, provision of mobile laboratories to schools lacking laboratory facilities and so forth. It was hoped that such measures and interventions would lead to improved education quality and learner performance in natural sciences.

In 2016, the Examination council of Zambia (ECZ) introduced practicals in science 5124, and the nomenclature of assessment changed from having theory examinations papers to the one incorporating both theory and practical papers. Science 5124 is a combination of two subjects namely; Chemistry and Physics. These subjects are taught separately but are considered as one subject in final examinations. Table 1 indicates the new structure for science 5124 examinations.

Table 1: Examination structure for Science 5124

Paper no.	Type of paper	Duration	Marks
1	**Physics theory paper** • Section A: 9 compulsory structured questions. • Section B: 3 questions from which candidates attempt 2 of them.	2 hours	85
2	**Chemistry theory paper** • Section A: 9 compulsory structured questions. • Section B: 3 questions from which candidates attempt 2 of them.	2 hours	85
3	**Practical paper** • 4 compulsory short practical questions (2 chemistry and 2 physics questions).	1:30 hours	40

Source: Performance report (ECZ, 2016).

The information in Table 1 shows that the total mark for science 5124 is the aggregate of the marks in physics and chemistry theory and practical papers. ECZ prepares practical examinations to test learners' acquisition of chemistry and physics practical skills which in essence are science process skills. In such practical examinations, learners are required to carry out practical activities following given instructions. These practical activities are in form of experiments (Siachibila, 2018). In case of chemistry practicals, there are usually two questions of which one is on qualitative analysis and the other one is on quantitative analysis.

Since the introduction of science 5124 practical paper, candidates have been displaying weaknesses in questions involving the use of science process skills in chemistry practical activities (ECZ 2016; 2017). These include poor recording of results and observations, failure to explain observations, failure to draw conclusions from observations, lack of in-depth knowledge on the use of scientific procedures and poor psychomotor skills in practicals among others. This problem could be attributed to learners' inability to use science process skills in practical tasks (Nweke, 2015; Omiko, 2013; Tobin & Capie, 1982; Valanides, 1996). This raises a great concern as literature has shown that acquisition and use of science process skills (SPS) is crucial both in science learning and the development of a society (Akani, 2015; Padilla, 2004).

1.3 Statement of the problem

Previously, ECZ used to administer theoretical examinations in science 5124, but following a curriculum review in 2013, a practical paper was incorporated. ECZ (2016; 2017) annual performance reports have revealed that candidates generally have been facing challenges related to use of science process skills in chemistry 5124 practicals, which lead to poor performance. However**,** no empirical study has been conducted to investigate learners' use of science process skills in chemistry 5124 practical activities particularly in a natural setting other than relying on candidates' examination scripts to make inferences in the Zambian context. This created a knowledge gap.

1.4 Purpose of the study

The study investigated use of science process skills by learners in chemistry 5124 practical activities in selected secondary schools of Kitwe district.

1.5 Research objectives

The objectives of the study were as follows:

i. To establish learners' views on the use of SPS in chemistry 5124 practical activities.

ii. To identify SPS learners use to conduct chemistry 5124 practical activities.

iii. To determine the level to which learners use SPS to conduct chemistry 5124 practical activities.

iv. To establish the relationship between learners' views on the use of SPS and the SPS learners use to conduct chemistry 5124 practical activities.

1.6 Research questions

The study was guided by the following questions:

i. What are learner's views on the use of SPS in chemistry 5124 practical activities?
ii. What SPS do learners use to conduct chemistry 5124 practical activities?
iii. To what level do learners use SPS to conduct chemistry 5124 practical activities?
iv. What is the relationship between learners' views on the use of SPS and the SPS learners use to conduct chemistry 5124 practical activities?

1.7 Research hypotheses

The following hypotheses guided the study.

Null hypothesis, H_0: There is no relationship between learners' views on the use of SPS and the SPS learners use to conduct chemistry 5124 practical activities.

Alternative hypothesis, H_1: There is a relationship between learners' views on the use of SPS and the SPS learners use to conduct chemistry 5124 practical activities.

1.8 Significance of the study

The findings of this study would help chemistry teachers in planning practical activities tailored to develop and enhance SPS in learners. This is important because SPS aid conceptual and procedural understanding, which in turn improves learner performance. Further, the findings will also contribute to already existing literature on SPS in chemistry 5124.

1.9 Delimitation of the study

The study was only conducted in selected government secondary schools of Kitwe district. Hence, findings in this study should not be generalized to other districts.

1.10 Limitation of the study

Due to limited materials and pieces of apparatus for chemistry practical activities in target schools, only a manageable number of learners per school were selected to participate in the study. In addition, the study adopted American Association for the Advancement of Sciences [AAAS], (1993) classification of science process skills and only considered observing, measuring, classifying, predicting, inferring, communicating and interpreting skills. Therefore, findings in this study should not be generalized to other categories of SPS.

1.11 Theoretical framework of the study

The study was guided by two theories namely; cognitive constructivist’s theory (Piaget, 1966) and activity theory (Leontiev, 1981). To start with, Piaget (1966) established one of the key theories to explain intellectual development of an individual. He investigated how individuals perceive their environment and the world around them. His investigation was based on observations and interviews with children about their reactions to events from birth to adolescence. The findings indicated that development of one’s cognitive structures (schemata) is dependent on individual to environment interaction. One of the resultant theories, cognitive constructivist’s theory, indicates that learning is a process in which individuals actively construct and build new knowledge based on their existing cognitive structures (prior knowledge) and new information on their own (Paour, 1990). As such, this theory was used to understand learner to practical activity interaction; in essence it helped to clarify how learners used their cognitive abilities, particularly SPS to conduct practical activities. Piaget (1966) observed that individuals face two processes, assimilation and accommodation in order to adapt to an environment. Assimilation is a cognitive process by which an individual integrates new perceptual, motor or conceptual matter into existing schemata or patterns of behavior (Wadsworth, 1996). If a learner is subjected to new experiences similar to previous one, she or he can easily adapt. Thus, it was envisaged in this study that if a learner has had used a certain SPS before, that skill would be used in various situations with little or no difficulties at all because pattern of this skill would have already been integrated into existing schemata.

Further, sometimes an individual may fail to assimilate new information or stimulus into existing schemata, and so he or she may create new schema in which to place the new information or modify an existing schema so that the new information fits into it (Wadsworth, 1996). This process is called accommodation. Huitt and Hummel (2003) defined accommodation as a process of changing cognitive structures in order to accept something from the environment. In order to understand accommodation with regard to use of SPS by learners in practical activities, let us consider the following scenarios. If we consider a learner who is undertaking a task which requires them to use a certain SPS, say predicting skill but fails or experiences difficulties in executing the skill. Then this would imply that this learner does not have existing schemata for predicting skill to assist them assimilate easily or is rather experiencing difficulties to modify existing schema so that the new stimulus can fit in it. Consequently, a learner would encounter difficulties on tasks requiring the use of predicting skill. Another scenario to consider is where a learner may not have successfully used a certain SPS in an activity. This could also be due to the task given being too advanced for them to undertake, a different situation from the previous one where the learner never used the said skill before. This is possible especially when the task given is beyond one’s cognitive level or ability, which in turn has potential to affect their comprehension (Piaget, 1964).

Advanced tasks demand for higher order intellectual abilities (Özgelen, 2012), which in this case could be the complex and integrated SPS. Some activities require learners to engage in more than simple thinking and use not less than one complex or integrated SPS. Therefore, learners engaged in advanced tasks are likely to be overwhelmed with cognitive load and this ultimately affects how they use SPS to conduct activities. It cannot be over-emphasized that the environment to which a learner has been pre-exposed affects their assimilating or accommodating abilities which ultimately influence how they use SPS. It should be noted also that use of SPS is influenced by ones cognitive level of development (Akani, 2015; Özgelen, 2012).

Furthermore, research has shown that individuals pass through four stages of cognitive development and these are in hierarchical order as follows; sensory motor, pre-operational, concrete operational and formal operational stages (Piaget, 1964). Huitt and Hummel (2003) indicated that in sensory motor stage, intelligence is demonstrated through motor activities without use of symbols. He further pointed out that, in the second (pre-operational) stage, intelligence is demonstrated through use of symbols, mature language use, and memory and imagination are developed, but thinking is done in a non-logical manner. It can be observed that during the first two stages of cognitive development, the sensory-motor actions are not immediately and fully translated into operations. Piaget (1964) described an operation as an interiorized and particular type of action which makes up logical structures. He further added that an operation does not exist in isolation; it is always linked to other operations and as a result is a part of a total structure of operations. One gets to know an object by performing operations on it. For instance, one cannot give logical measurement of a substance without performing operations on it, such as observing, transforming, and understanding its physical state among others. Thus, a series of operations are what constitutes the basis of knowledge with regard to which we must understand the formation, organization and development of knowledge and its applications (Piaget, 1964). The third (concrete operational) stage is where intelligence is demonstrated through logical and systematic manipulation of symbols related to concrete objects (Huitt & Hummel, 2003). The fourth (formal operational) stage is characterized by one's ability to handle abstract concepts and experiences. Hence, during the third and fourth stages of cognitive development, the sensory-motor actions are successfully and fully translated into operations. Therefore, it can be noted that one's cognitive developmental level actually affects how they would use SPS in given activities.

Brotherton and Preece (1996) observed that concrete operational stage is mainly characterized by basic SPS while the formal operational stage is largely characterized by complex and integrated SPS. This implies that learners who have attained concrete operational level are more likely to succeed in using basic SPS, but are less likely to succeed and would face difficulties when using complex and integrated SPS. This is because at this stage, they may not have yet developed cognitive structures to deal with abstract and complex tasks. On the other hand, those who have attained formal operational stage are more likely to succeed in using both basic and integrated skills with minimal or no difficulties in given activities because they would have developed intellectual structures to deal with abstract, advanced and complex tasks.

Additionally, cognitive constructivism focuses on the cognitive developmental processes by which an individual form abstract conceptual understanding from their experience (Mweshi, 2007). It advocates that conceptual development occurs through individual mental adaptation as emergent ideas are tested and found to work and to make sense of one's surroundings (Parkinson, 1994). Hence, one's cognitive activity influences how they perceive and respond to the environment they subjected to. The process skills are the learner's cognitive activity of creating meaning and structure from new information and experience (Mikalsen & Oyunniyi, 2004). Despite one's cognitive processes (e. g thinking) not being observable directly, actions can reflect these processes (McGregor, 2007; Özgelen, 2012). This implies that it is possible to determine one's cognitive process, like SPS, by observing his or her action(s). In this study, this was achieved by engaging learners in standardized activities which were tailored to induce use of specific SPS. In a nutshell, cognitive constructivist's theory guided on the choice of SPS to investigate, sample characteristics, results analysis, discuss of findings and subsequently, recommendation. How to investigate such skills and ground analysis was to a larger extent complemented by activity theory. The cognitive theory seems not to be so explicit on how one's cognition is linked to his or her psychomotor skills. Therefore, activity theory was incorporated in this study to account for such transition.

Activity theory mainly focuses on mediation and tools used in human activity. Kaptelinin and Nardi (2018) argued that due to flexibility and versatility nature of activity theory, it is usually combined with other theories like cognitive related theories to offer researchers useful insights and guidance in their studies. Clemmensen, Kaptelinin and Nardi (2016) observed that activity theory combined with other less sweeping theories offers accuracy and specificity. Activity theory is a psycho-social theory which seeks to offer an understanding of the unity of consciousness and activity. It is a theory with profound insights into the fundamentals of human consciousness, actions and reasoning, and interpreting these processes as outcomes of an individual's interaction with others and artifacts in a social environment (Hasan & Kazlauskas, 2014; Kaptelinin & Nardi, 2012; Vygotsky, 1978). Hasan and Kazlauskas (2014) pointed out that human activity is purposeful and carried out by sets of actions through the use of tools, which can be physical or psychological. They further indicated that an activity both mediates, and is mediated by the tools used, as well as the social context of an activity. This implies that mediation offers two-way perspective; the capability and availability of tools mediates what can be done in an activity, and the activity in turn determines how and to what extent a certain tool is used to perform a particular action. In this study, laboratory apparatus and equipment among others could be regarded as physical tools while SPS as psychological ones. Thus, it was envisioned that successful use of SPS in chemistry practical activities was possible only when the aforementioned physical tools were in good condition and used effectively.

Hasan and Kazlauskas (2014) indicated that, activity theory is all about 'who is doing what, why and how?'. They further posited that it is the relationship between the human doer (learner in our case) and the thing being done (activity's focus and purpose) which forms the core of an activity. This is important to note because the intended outcomes of an activity are mostly accompanied by unintended ones which can be open to other interpretations. Therefore, there is need to clearly plan and design activities in order to ensure that desired objectives are achieved.

Finally, activity theory was particularly used as an analytical lens for characterizing the process of designing practical activities and the means by which learners used SPS to carry out practical activities. Under this theory, learners were viewed as doers who used laboratory apparatus and equipment as well as SPS as mediation tools to carry out chemistry practical activities. It was my conception that the two theories, cognitive constructivist's theory and activity theory, are synergetic theoretical frameworks which when used together would provide a richer perspective and understanding in the study than either could offer in isolation.

1.12 Conceptual framework

The conceptual framework of the study is shown in Figure 1.

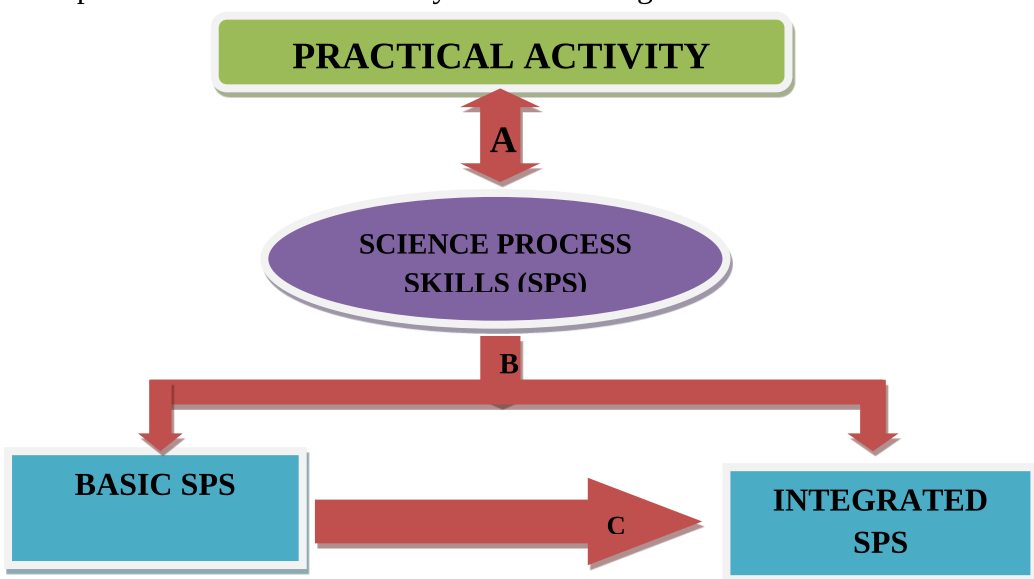


Figure 1: Relationship of variables in the study.

Figure 1 demonstrates the relationship between practical activity and SPS. The double arrow (A) indicates a two-way relationship between practical activity and SPS. These two are interdependent. Practical activity both mediates, and is mediated by the SPS. On one hand, ones SPS influences how he or she perceives and makes sense of an activity, while on the other use of SPS is dependent on the nature of activity being undertaken. The activity informs the type of SPS and how that can be used by an individual. This means that use of SPS is limited to the task of an activity being carried out. Thus, in this study, standardized activity (SPSAI) was administered to learners to ensure uniformity in SPS used in task given during data collection. SPS are categorized as either basic SPS or integrated SPS as indicated by arrow B. Integrated SPS are called so because they are a combination of two or more basic SPS. Hence, arrow C which indicates that integrated SPS are dependent on basic SPS. It is important to note that SPS appeals to cognitive domain differently. That is why basic SPS are also referred to as lower order thinking skills while integrated SPS are called higher order skills. One's cognitive level affects how he or she uses SPS. The cognitive level of an individual could also influence how one interprets a given activity. Therefore, the study only considered learners of the same grade level (grade 12) with the assumption that such were at the same mental level so as to remove biasness from the participants.

1.13 Operational definitions

i. Learners: all grade 12 internal pupils who learn chemistry 5124 as a compulsory subject.

ii. Practical activity: any learning task which require learners to use one or more science process skills as they interact with scientific phenomena under the study.

iii. Science process skills: are intellectual abilities, and methods which enable one to explore scientific phenomena, formulate and analyze results, and eventually construct knowledge in order to solve given problems.

1.14 Ethical considerations of the study

Firstly, clearance was obtained from the University of Zambia Ethics committee (refer to Appendix E). Thereafter, permission and arrangements were sought and made through physical visits with relevant school authorities (refer to Appendix F). Later on, participants' consents to participate in the study were obtained (refer to Appendix G). Finally, confidentiality was upheld in this study by means of using arbitrary codes as opposed to use of actual names of schools and participants.

1.15 Chapter summary

This chapter looked at the background to the study based on the Zambian science 5124 curriculum and ECZ examinations' annual reports. It presented statement of the problem in relation to the background to the study, literature and based on researcher's knowledge. Research objectives, questions and hypotheses were presented with respect to the knowledge gaps identified from literature. The chapter further outlined the cognitive constructivist's and activity theories as theoretical frameworks which underpinned the study. Key terms of the study were operationally defined. Finally, ethical issues were outlined in this chapter. The next chapter looks at literature review.

1.16 Organisation of the dissertation

Chapter 1 introduces the study by giving the background to the study. It also outlines key items which includes the statement of the problem, purpose of the study, study objectives as well as questions/hypotheses. It further describes the significance, delimitation and limitation of the study, theoretical and conceptual frameworks, operation definitions, ethical considerations and finally summary of the chapter.

Chapter 2 presents a review of literature related to the issue under investigation. Literature review is presented under the following headings: What are science process skills, Science process skills applied to the learning of chemistry, Literature on science process skills across the globe, Literature on science process skills in Zambia, The teaching of Science Process Skills in schools and lastly chapter summary.

Chapter 3 describes research methodology which includes the philosophical underpinning, research approach and design. It also describes the study site, study population, study sample and sampling techniques. It further looks at data collection instruments, and their reliability and validity. It ends by outlining data collection and analysis procedures and chapter summary.

Chapter 4 looks at presentation of study findings. Both qualitative and quantitative findings are presented simultaneously. The chapter presents findings according to research questions and instruments. Section 4.2, 4.3, 4.4 and 4.5 presents findings for the first, second, third and fourth research questions respectively. The chapter ends with a summary.

Chapter 5 gives the discussion of findings presented in chapter 4 in line with research objectives. The findings are discussed in line with reviewed literature and the theoretical framework under the following headings: views of learners on the use of SPS, SPS learners used to conduct chemistry practical activities, learners' level of use of science process skills to conduct chemistry practical activities and the relationship between learners' views on the use of science process skills and the science process skills learners used to conduct chemistry practical activities. Lastly, it gives a chapter summary.

Chapter 6 presents the study conclusion and recommendations based on current study findings. The conclusions and recommendations are presented according to research objectives. The chapter ends with a summary.

CHAPTER 2

REVIEW OF RELATED LITERATURE

2.1 Overview

This chapter reviews literature related to the study. It starts by looking at what science process skills are, and their application to the learning of chemistry. It also looks at studies on Science process skills conducted across the globe and then narrows to those carried out in Zambia. Thereafter, the teaching of science process skills in schools and chapter summary are presented.

2.2 What are Science process skills?

Different scholars have defined and explained science process skills based on their intellectual disposition (Karamustafaoglu, 2011; Özgelen, 2012; Padilla, 1990). For example, Padilla (1990) explained that science process skills are 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. He further described science process skills as a set of broadly transferrable abilities, appropriate to many science disciplines and reflective of the behavior of scientists. It is clear that this definition is inclined and to some extent restricts science process skills to transferable abilities only. It is also not clear what he meant by ‘transferrable abilities’, and whether the said abilities are physical or mental abilities. According to Bredderman (1983) science process skills are cognitive skills which are used to understand and develop the information.

Özgelen (2012) indicated that science process skills are the thinking skills that scientists use to construct knowledge in order to solve problems and formulate results. He further explained that these are cognitive processes which are reflected by one’s actions. He referred to scientific thinking, critical thinking and scientific methods as a way of description. This definition implies that these skills are mental abilities. However, he restricted these process skills to scientists only and neglected other knowledge constructors and problem solvers such as learners and teachers who too in their learning and teaching experiences use them. Karamustafaoglu (2011) explained science process skills in terms of their purpose by pointing out that, they are special skills that simplify learning of science, activate students, develop student's sense of responsibility in their own learning, increase the permanence of learning as well as teach them the research methods. Therefore, Karamustafaoglu's (2011) and Özgelen's (2012) descriptions of SPSs appeal to the researcher, as they explicitly clarify what science process skills are. He holds the view that there could be no description more explicit than a blend of the two, for they do not only relate science process skills to one's conceptual understanding but also to their procedural understanding in a given task.

Science process skills are classified into two categories namely basic and integrated science process skills (Ango, 1992). The basic (simpler) process skills provide a foundation for learning the integrated (more complex) skills (Padilla, 1990). Basic process skills include observing, measuring, predicting, classifying, inferring and communicating (Ango, 1992; Bybee et al., 1989). They are called basic skills because they are simple and lower order thinking skills. The other continuum of process skills are integrated skills. Ango (1992) indicated that integrated science process skills include interpreting data, questioning, controlling variables, defining operationally, formulating models, hypothesizing and designing experiments or experimenting. They are called so because one integrated skill is a combination of two or more basic process skills. For instance, one cannot perform experimenting skill effectively unless they master a range of basic process skills like observing, classifying, measuring and so forth. The entire process of experimenting calls for application of almost all science process skills in a scientific inquiry. In another example, for one to control the variable they must be able to predict or infer what effect such a variable would have in an experiment. Science process skills are in most cases dependent on each other in practice. They, not only integrated skills, but also basic process skills overlap and intertwine with one another. In essence they form a web like pattern. Figure 2 depicts the hierarchical nature, interrelatedness and complexity of science process skills.

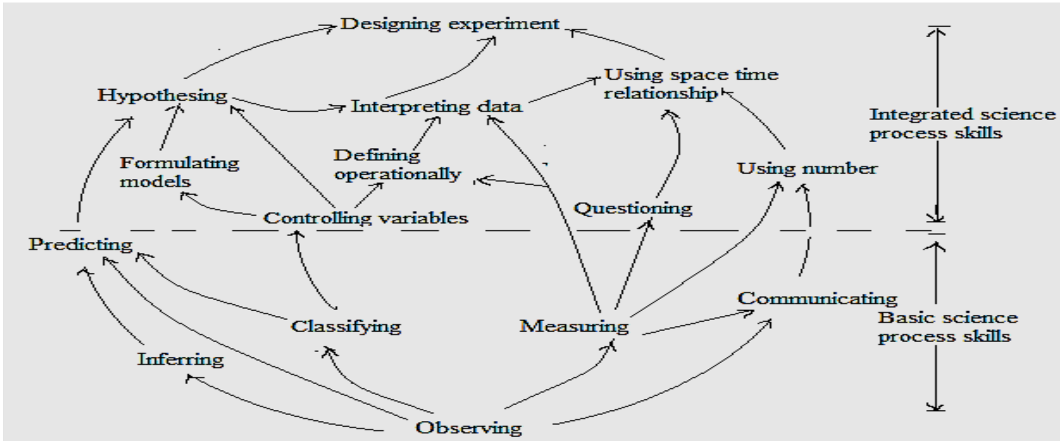


Figure 2: Hierarchical nature of Science process skills (Rezba et al., as cited in Rambuda, 2002)

As shown in Figure 2, the foundation of all the skills is the observing skill and experimenting is the most complex skill. The diagram indicates that development or use of one skill is hierarchical in nature as formation of one depends on the formation of other skills especially integrated science process skills. Basic science process skills have to be mastered before one can gain dominance in integrated science process skills. This view is also supported by Piaget (1964), in that learners can master abstract thinking in higher order thinking skills (integrated process skills) provided they have complete control of lower order skills (basic process skills).

It is worth noting that science process skills have been in existence as long as science has ever existed. Scientists have employed process skills to discover or create knowledge, prove or form theories, devise solutions among others, whether with or without knowledge of science process skills. By extension science process skills are the ultimate tools which have been used and are still mostly used by students in science activities to solve scientific problems. However, studies aiming at developing school programmes to improve science process skills began in 1960s (Brotherton & Preece, 1996). A recurring issue in science education has been concerned with the emphasis to be given to methods of teaching science which accentuate science process skills in school science curriculum. Department of Education and Science (DES) and American Association for Advancement of Science (AAAS) were first to conduct studies on the issue in England in 1960 and USA in 1967 respectively. Henceforth, many studies followed and have indicated that science process skills are vital in the teaching and learning of science (Brotherton & Preece, 1996; Mweshi, 2007; Rambuda, 2002).

2.3 Science process skills applied to the learning of chemistry

Theories of learning like Piaget's supports the development of science process skills in learning. Chemistry learning experiences should facilitate and enhance the development of learners' thinking skills through the use of science process skills. This can be achieved by employing process skill approaches such as exploration, inquiry and discovery learning. In this regard, instructors ought to provide learners with opportunities to discover scientific knowledge through abstract reasoning and active manipulation of concrete materials (Rambuda, 2002). Piaget (1964) revealed that children are active discoverers, inventors and problem solvers. This implies that learners should be encouraged to interact with scientific phenomena and their environment in order to discover knowledge for themselves, while teachers playing a role of a facilitator. This idea of individual's self-acquisition of knowledge compels teachers to provide learning opportunities in which learners experience scientific phenomena. The researcher is of the view that teachers should teach the full content (knowledge, skills and values) of science. This means, knowledge-based teaching should be supplemented with process-based teaching which is likely to develop and promote intellectual activities that may enhance learners' cognitive development. Scientific attitudes are reinforced by scientific values which only come in when one is able to appreciate the two domains (knowledge and process skills).

Teachers should ensure that learners fully develop basic process skills before they are subjected to tasks that involve use of integrated skills. Once learners have acquired and mastered basic science process skills, teachers should introduce activities which demand for use of integrated process skills in abstracting scientific ideas (Brotherton & Preece, 1996; Özgelen, 2012). These activities are likely to develop and enhance higher order thinking skills in Chemistry learners that may enhance reflective thinking, analysis, synthesis and evaluation.

2.3.1 Observing skill in chemistry practical activities

Observing is using the senses to gather information or data about an object or event (Padilla, 1990). It is a basic skill of scientific inquiry. Individuals observe through all their senses ranging from sight, touch, smell, and taste to hearing. We observe in order to obtain information about the environment or to identify features or changes in phenomena and to interpret those changes (Zeitler & Barufaldi, 1988). For instance, learners may be given a practical activity in which they are required to identify a chemical reaction being carried out in a beaker or test tube as either exothermic or endothermic. Learners would identify the reaction by simply observing temperature changes of the reaction. In this case, they would tell the rise or drop in temperature through making contact with the beaker and determine whether it is hot or cold before and after the reaction. By this learner would have identified changes in temperature through feelings achieved by touching the beaker. In some cases, they may use an instrument (thermometer) to tell the changes in temperature. Learners would insert a thermometer into the beaker where the reaction is taking place and carefully observe the temperature changes. Here observation could be made through the sense of sight by getting the reading on a thermometer.

Van Aswegen et al. (1993) noted that the ability of learners is likely to improve in experimental observations if teachers and learners adhere to the following principles:

i. Accuracy- the phenomenon being observed should be exact to ensure accurate and correct observations.
ii. Relevancy- learners should be prepared with relevant knowledge and skills before undertaking the activity, this would enable them make scientific observations relevant.
iii. Realism- learners should be provided with opportunities to observe scientific realities, that is, they should observe the actual scientific phenomena.
iv. Comprehensibility- the activity, procedure, and demonstration should be at the developmental level of the learners. It is possible for learners not to grasp observations that could be beyond their cognitive level or ability.

How can one tell whether the observation made is correct? This and many other questions fill the minds of infant investigators in science. The answer here is, observation is theory-laden, what individuals observe depends on proven theories (Zeitler & Barufaldi 1988). Theory guides observation, and without it one is incapable of making sense of observation or make correct observations. Without a theory to guide, irrelevant data would necessarily be collected. Millar and Driver (1987) pointed out that, a theory provides guidance on what we expect to see in certain situations, on which feature of the event to observe and what or where to focus attention. All these preceding arguments clearly illustrate that observation is theory dependent. Sometimes investigation would not seek to prove but to establish a theory. In this case one does not need a theory at the beginning of an investigation but rather would arrive at it at the end of it. Other theories could be used as guiding principles in an inquiry. Both cases are possible because scientific investigations could either be inductive or deductive. It is worth noting that some observation*s* need to be quantified also known as 'measuring' in order to make accurate observations.

2.3.2 Measuring skill in chemistry practical activities

Measuring is making both standard and nonstandard measures and estimates to describe the dimensions of an object or event (Padilla, 1990). Van Aswegen et al. (1993) asserted that scientists are able to express their observations in more precise terms through measuring. Measuring is a skill for quantitative observations and for communicating effectively with others. Zeitler and Barufaldi (1988) maintain that measuring quantifies through numbers. Objects or events can be quantified with standard or non-standard units. To apply the standard unit of measuring one need to use an instrument or apparatus, as was the case when a thermometer was used to measure temperature changes for the chemical reaction of the example in the previous section. To use non-standard unit of measuring one needs to use their senses. Like in the earlier example to identify a chemical reaction as either exothermic or endothermic, a learner needed to touch a beaker thereby using a sense of feeling to draw an inference. Measuring to a larger extent is dependent on phenomena being measured and the measuring instruments. After the measuring process, learners may be forced to give meaning to measured values or what they measured. One means by which they can give meaning is through classification.

2.3.3 Classifying skill in chemistry practical activities

Classifying skill is a process skill that involves the arrangement or ordering of objects or events into different groups or categories based on properties or criteria (Rambuda, 2002). Each classified group may have objects or events which have common features. Classification implies a relation of resemblance between items of the same class, or dissimilarity between items of different classes. Millar (1989) argued that all people possess the ability to classify. In learning classification is used for convenience and to further understanding of objects or events. Kuhn (1977) indicated that all learning depends on learner capability to classify. When determining the basis for any classification in the learning experience, teachers ought to ensure that learners are capable of using a particular system of classification. Learners should know the purpose for classification and be allowed to choose relevant criteria for classification. This promotes independent thinking, an attitude which is so much desired to be inherent among learners. Teachers should also encourage learners to make predictions in chemistry practical activities.

2.3.4 Predicting skill in chemistry practical activities

Padilla (1990) indicated that predicting is stating the outcome of a future event based on pattern of evidence. It is more than a mere guess, but rather a scientific guess. Prediction is based on background information and experiences (Zeitler & Barufaldi, 1988). Prediction entails identifying the possibility rather than the assurance of the event. For example, learners may predict what the results would be in a given chemistry experiment. Later on, they can compare their predictions with actual results obtained at the end of the activity. This would not only develop predicting skill in learners but also attitudes such as respect for evidence. Van Aswegen et al. (1993) recommended that teachers should develop the skill of prediction in learners by asking questions such as “What will happen if ...” This type of questioning does not only stimulate predicting skill but also encourages learners to think about observations made in experiments. In this vein teachers are encouraged to ask probing questions to qualify the learners' answers not just focusing on the right answer. This way, learners can be challenged to think critically and analytically about their answers than just give a guess or correct answer. It is evident that predicting paves way to interpreting skill.

2.3.5 Interpreting skill in chemistry practical activities

Organizing data and drawing conclusions from it, and eventually attaching meaning to it, is what is referred to as interpreting. Learners in chemistry are more often subjected to tasks which demand interpretation of certain phenomenon. For instance, learners may be required to interpret a graph for a given rate of reaction. A graph without interpretation means nothing, apart from having drawings and numbers. Interpreting is an integrated process skill and as such is higher order thinking skill. This implies that basic process skills lay the foundation to this skill. Interpreting skill can develop gradually in learners. Thus, the better a learner becomes at executing basic skills the higher the chances of becoming good at interpreting. Therefore, learners should be encouraged to practice and master basic process skills in order for them to become experts at interpreting. In some cases, learners may observe and interpret data from observations but may be required to draw conclusion to give meaning to what they observed. This act of attaching meaning to observation is called inference or inferring.

2.3.6 Inferring skill in chemistry practical activities

Inferring is giving explanations or drawing conclusion based on observations made or data collected. It is worth noting that this skill is complex as it builds on other process skills. For instance, one needs to have collected data or made observations in order for them to make an inference. Teachers may ask learners to make inference during or at the end of chemistry experiments and communicate their results.

2.3.7 Communicating skill in chemistry practical activities

We use words or graphic symbols to describe an action, object or event in our day to day lives. This act is what is referred to as communicating. Despite, communicating being a basic process skill, it is much more complex. Zeitler and Barufaldi (1988) maintained that people need good understanding of scientific terminologies to communicate effectively. Learners need to understand the meaning of terms if they are to explain interaction between phenomena or the results of a reaction in an acceptable way. Van Aswegen et al. (1993) stated that learners should be given opportunities to think and to communicate their thoughts into spoken and written words, diagrams, graphs, pictures and equations. One needs to understand the means of communicating if they are to communicate effectively in a particular language. With respect to Chemistry, learners should be encouraged to be conversant with the language of chemistry and to communicate in acceptable ways if they are to learn chemistry in an effective and efficient manner. Use of practical activities in chemistry is likely to encourage learners to apply most of science process skills in their investigations. As noted earlier, the development of science process skills may empower learners to be active when learning chemistry.

2.4 Literature on science process skills across the globe

Quite a number of studies have been conducted on science process skills across the globe. For instance, Rambuda (2002) conducted a study in which he investigated the application of science process skills to the teaching of geography in secondary schools in South Africa. A mixed method approach was used with interview guides and questionnaires as main data collection instruments. The study revealed that teachers and learners were of the view that teachers used inquiry methods, and only applied basic science process skills in the teaching of geography. This suggests how important science process skills are to learning experiences to the extent that they can even help to enhance learning experiences of a range of subjects at secondary schools. However, the study did not establish how learners' views on science process skills would affect their performance in a given learning activity due to the nature of the approach used. It relied too much on participants' opinions, and so trustworthiness of results could have been compromised to some extent. In contrast, studies of this nature require an empirical approach so as to establish in detail how process skills are applied in the learning experience.

Despite the availability of process-oriented science activities for more than decades, literature suggests that learners from elementary grades through college experience difficulties in using process skills to solve problems (Jaus, 1975; Kyle, Penick, & Shymansky, 1979; Tobin & Capie, 1982). In an endeavor to improve process skills among learners, many studies have been carried out to establish how various strategies, approaches and methods influence learners' science process skills. Karamustafaoglu (2011) suggested that science process skills can be taught through various approaches, strategies and methods. The question as to why an individual need to acquire and develop science process skills is what ought to be answered by every science educator. This is vital owing to the fact that science process skills are crucial for meaningful learning. As learning continues throughout one's life, an individual would need these skills if they are to succeed in investigating, interpreting, and judging evidence under different conditions they encounter in life. Therefore, it is essential for the students' future to be provided with science process skills in educational institutions (Harlen, 1999). If these skills are not developed sufficiently, students would not make correct observations, interpret the knowledge collected or collect evidence in an effort to solve a problem at hand. If related evidence is not collected, science concepts only would not help students to understand certain scientific phenomena or what takes place in given scientific events (Tobin, Kahle & Fraser, 1990). This and many other reasons explain why the aim in science classes should be teaching students how to attain knowledge rather than just passing the convenient knowledge. Science process skills have influence on learners' achievement in science and science related subjects or professions.

Further, Abangu, Okere and Wachanga (2014) investigated the effect of science process skills teaching approach on students' achievement in chemistry. The study used a Solomon four group Quasi-experimental design with 153 grade 10 students. The findings revealed that science process skills teaching approach had a significant effect on students' achievement in chemistry. The outcome of this study may provide an insight for designing instructional strategies that aim at enhancing students' process skills in the effort to improve their performance, and also contribute to the improvement of teaching and learning of chemistry in secondary schools.

It is worth noting that individuals possess and use science process skills differently in different circumstances. Several studies have been conducted in this regard. A study which seems to explicitly answer a question, as to why individuals use science process skills differently was the one done in Turkey by Özgelen (2012). The study sought to investigate Turkish primary students' science process skills under the theoretical framework of cognitive domain. The study used Turkish integrated process skills test to measure science process skills and the findings generally showed low scores. The study revealed significant differences between sixth and seventh grade learners in both private and public schools. These differences were explained under the cognitive domain framework. Such differences in scores were possible because learners were at different developmental levels, and so they processed information differently. Piaget (1964) claimed a positive correlation between children's mental capacity for processing information and their age. The reason why the scores were low is evident that tasks given were too advanced to learners. Students at concrete operational stage can successfully implement basic process skills, and those at formal operational stage can successfully implement integrated process skills (Brotherton & Preece, 1996). Therefore, the aforementioned study finding shows an insufficient cognitive level or lack of development of formal reasoning patterns among the learners.

A study in Nigeria by Akani (2015), investigated the level of possession of science process skills by final year students in colleges of education in South Eastern States. The skills assessed were observing, experimenting, measuring, communicating, and inferring. The study used science process skills Tests and a 28-item Assessment format for science process skills to collect data. The results indicated that there was high level possession of observing, experimenting and measuring skills and low-level possession of communicating and inferring skills by the respondents. This study is vital as it assessed mostly the basic but not inferior skills which are building blocks to integrated process skills. However, the study concentrated only on lower level process skills, while the level of participants was too high to be assessed on this scale. College students are expected to have attained higher older thinking and so are capable of successfully implementing integrated process skills with little or less difficulties. Therefore, it could have been interesting if the study investigated how such skills were acquired than just their assessment. The study did not establish what led to the cause of a strange trend observed in the findings, which was high level possession of experimenting while low level possession was communication. This is not consistent with scientific expectation because integrated skills like experimenting are higher order and builds on basic skills like communication (Özgelen, 2012). Using different methods, instruments and approach in the study would have helped to address the strange trend observed.

Furthermore, several studies have been conducted to ascertain the effect that science process skills have on learners' academic performance, and the results in most cases have been a 'positive correlation'. For instance, Feyzioglu (2009) investigated whether science process skills and efficient laboratory use are significantly correlated with the university students' basic chemistry course achievement. Questionnaire, efficient laboratory attitude scale and science achievement test were used as data collection instruments. The study established that there was a positive linear relationship between science process skills taught in laboratory application and efficient laboratory use by students. It further highlighted that science process skills and achievement in the course have a positive correlation. This substantiates the importance of emphasizing on efficient use of laboratory apparatus, instruments, safety measures and so forth by learners if science process skills are to be developed and improved in learners. This also implies that process skills can be taught in an environment which favors their use.

Another study in a similar vein was done by Aydogdu (2017) which investigated the relationship between Turkish primary school students' basic process skills and their academic achievement. The study employed a survey design and data were obtained from the adapted 'Test of Basic Process Skills (BAPS)'. The findings of the study revealed that there was a positive relationship between basic process skills of primary school students and their achievement in science subjects. Additionally, BAPS scores of the participants were not at a satisfactory level, and scores of primary school students were higher among the upper grades than the lower grades. The study further found that scores of primary school students were higher among students coming from better socio-economic levels than those with low level socio-economic backgrounds. This study is important as it has great bearing on the teaching and learning experiences as well as research enterprises. The findings of this study imply that teachers have the great responsibility to help learners develop basic science process skills. Teachers or researchers ought to take into account the socio-economic levels of learners or participants when planning for in-class activities that focus on basic process skills of primary school learners. This idea can be extended to all grade levels. Lastly, the findings also seem to suggest that the more basic process skills primary school students acquire, the more academically successful they will be. Hence, teacher's obligation is to ensure that learners acquire basic process skills as early as possible, particularly during their lower grade levels. This would make them gain mastery of basic skills to the end that they would face minimal or no difficulties when exposed to integrated skills particularly found in higher grades.

2.5. Literature on science process skills in Zambia

In Zambia, Mweshi (2007) did a study that investigated the use of process skills approach by Zambia Teacher Education Course student teachers in Kitwe District. The study revealed that student teachers did not have adequate understanding of the science process skills approach and lacked practical experience of how to plan and implement the approach. Particularly, student teachers did not have adequate knowledge and pedagogical knowledge on how to identify process skills, plan for them and teach them. Mweshi (2007) attributed this inadequacy to students' weak background in science. This is worrying to would-be teachers and the learning environment, as the current trend demands for teachers to possess both Pedagogy and Content Knowledge of the subject matter in order to teach effectively. This study was addressed from the teachers' perspective, thus a process skill approach. As a result, the study does not show the use of process skills by learners. It is not known the type of process skills learners possess, their views on process skills and how such views influence their problem-solving abilities in chemistry practical activities.

In addition, Mulenga and Mbewe (2017) investigated the quality of school physics practical work in Zambia using a mixed methods approach. One of the objectives particularly looked at learners' ability to demonstrate transferrable skills in practical work. Findings from questionnaires showed significant disparity with findings from observations regarding the ability of learners to demonstrate transferrable skills. They revealed that responses of learners from survey on ability to use science process skills in physics practical activities were not consistent with the observations from the actual practice. Particularly, most learners were not able to demonstrate the skills they claimed they could demonstrate, as such it was concluded that learners did not demonstrate transferrable skills in physics practical work. This finding is important as it informs the researcher of reliability of study findings, and viability of research methods when certain phenomena are investigated from both the researcher's and participant's perspectives. To ensure validity and reliability of findings in the study, some research principles such as the one used here ought to be adhered to. Several data collection methods were employed (triangulation). In as much as the Mulenga and Mbewe's (2017) study is informative it did not establish the level of performance on use of SPSs by learners. Besides, the study was done in physics, grades 11 and 12, therefore it is not known whether similar results would be arrived at in chemistry 5124.

Siachibila (2018) assessed the science process skills inherent in the Examination Council of Zambia chemistry 5070 practical examinations from 2007 to 2016. The study revealed that the science process skills prominent in practical examinations during that period were observing, measuring, communicating, experimenting and interpreting data. It was deduced that ECZ included more basic science process skills (80.5 %) compared to integrated science process skills (19.5%) in its national examination for the period of 10 years. These results are similar to the findings of the study by Akinbobola and Afolabi (2010) which analyzed the science process skills in West African senior secondary school certificate physics practical examinations in Nigeria from 1998-2007. Their findings too revealed that there were more basic science process skills (63%) as compared to the integrated science process skills (37%). Considering the two studies it can be inferred that Zambia's chemistry national examinations from 2007-2016 included more basic process skills compared to Nigeria's physics national examination from 1998-2007. This has an implication on learners' understanding of chemistry content for basic process skills alone are not enough to help them develop necessary higher thinking skills such as problem solving, creativity, evaluative, innovative, inquiry and inventive among others.

In both cases, Siachibila (2018), and Akinbobola and Afolabi (2010) did document analyses of chemistry examination and physics examination respectively, but did not consider the subjects from the learner's point of view in a classroom setting. Hence, the study did not establish whether learners can exhibit the same trend 'more of basic than integrated process skills' in reality. This approach did not establish other factors such as challenges or difficulties learners encounter when conducting practical activities in a classroom among others.

Moreover, the Zambian annual examination performance reports for 2016 and 2017 revealed that, candidates faced challenges in chemistry-5124 practical examinations which included: poor layout of results, failure to explain observations and draw conclusions from observations, not relating their observations and results to the qualitative analysis notes provided, and poor psychomotor skills in practicals among others (ECZ, 2016; 2017). As highlighted above the prominent process skills which learners had challenges in executing in these consecutive examinations are communicating, observing, measuring, inferring and interpreting data. Gott and Mashiter (as cited by Mweshi, 2007) indicated that science process skills mediate conceptual and procedural understanding in the solution of a scientific task. Therefore, the aforementioned observations have implications on the learning of chemistry by learners. However, this observation by ECZ was based on the examination scripts and it is not known whether the same challenges could be arrived at in class room setting.

2.6 The teaching of Science Process Skills in schools

There has been debate for several years now as to whether science process skills should be taught in schools or not. Some scholars advocate for the idea while others hold the view that everyone is born with these skills and so there is no need to teach them. Millar (1989) questioned the possibility to teach science process skills according to the scientific method because cognitive processes are not transferrable. Some process skills cannot be transferred from an individual to another. He criticized the idea that learners can be taught some process skills such as observing, classifying, inferring and hypothesizing, because these skills are present in infants since birth. He argued that babies can observe, classify and infer without being taught. They are able to observe and classify different faces and identify their mothers. Thus, it is very difficult to prove if skills such as observing, classifying and hypothesizing can be taught and transferred to a new situation different from the original one (Millar 1991). This implies that science process skills can be transferred only linearly, that is transferrable to a situation similar to the original one. This is so because when transferring process skills, learners use reasoning by analogy rather than the application of general rules or procedure to understand (Millar & Driver 1987).

Many studies have been conducted and have established that instructions where science process skills are deliberately taken into account have positive correlation on students' performance. A study by Strawitz (1993) examined the effects of different strategies on the science process skill achievement of students using programmed instruction. The findings revealed that programmed instruction was more effective in helping students learn process skills than non-programmed. This means process skills can be planned for and taught to learners. Hence, the researcher holds the view that learners can be taught to observe, classify, measure and predict among other process skills in a scientific way. For instance, in a Chemistry inquiry learner can be taught to make observations either qualitative or quantitative. In this case they learn to explore properties of some scientific phenomenon. Properties which may include mass, molar mass, volume, temperature, color, concentration and so forth. Learners would not know these until they are taught or guided. As a result, the researcher concludes that it is possible to teach and aid development of science process skills so long learners are afforded learning opportunities in which they can use such skills to solve a given task.

In addition, this is why a process skill approach is widely considered in curricula of many countries and is emphasized across the world. However, Jenkins (1989) regarded the process-led approach as flawed because some skills such as accuracy, neatness and observing do not transfer. The advocate of content-oriented approach contends that process skills cannot be practiced in isolation of knowledge or experience. People use their knowledge and experiences whenever they use such skills as observing, classifying, inferring, predicting and so forth. Millar and Driver (1987) noted that knowledge gives meaning and value to science process skills as intellectual skills are applied during the life-cycle of a person. Non-advocates argue that they do not have any idea of how to teach these science process skills because what constitutes the growth or progression in science process skills is not known (Millar & Driver, 1987). These arguments are flawed because not all science process skills can be practiced without an experience and without receiving formal instructions. It is not possible for a learner to recognize variables and control them without learning what those variables are and how to handle them. It is possible to notice the strides made by the learner in process skills as this is visible when they apply learnt science process skills to new situations. For instance, a learner who successfully carries out an investigation in a scientific inquiry up to the end and arrives at desired results has demonstrated a higher order process skill (experimenting) which subsumes all the other process skills. The other skills can be used as strides in determining achievement of experimenting skill. This proves progress and growth in process skills in conducting scientific inquiry that is supported by evidence. Therefore, the researcher argues for the idea of using process skills in teaching and learning of Chemistry, that it is possible to develop process skills in learners and nurture them into sophisticated ones.

Furthermore, over the years there has been continuous emphasis on the need for individuals who are scientifically literate and proficient in the use of science process skills to make it explicit on the effective strategies for teaching these skills. A review of literature on the use of different strategies for teaching process skills indicates that some have proven not to be effective (Strawitz, 1993), whereas others have been quite effective (Jaus, 1975; Strawitz & Malone, 1987; Zeitler, 1981). Hence, use of effective strategies to teach science process skills has consistent and strong effects on students' learning, such as ones in which learners engage in minds to hands-on activities which allow them to construct meaning. Strawitz (1993) noted that such process skills and strategies should be reinforced in the context of meaningful investigations.

Finally, time and again studies have shown that pre-service and in-service teachers as well as students at all levels of education are deficient in science process skills (Kyle, Penick, & Shymansky, 1979; Mbewe, Chabalengula & Mumba, 2010; Mweshi, 2007). If educators have inadequacies in science process skills how and what can they teach to learners? This trend is worrisome as literature has shown that teacher process skill proficiency is positively related to; learner process skills proficiency, their development of formal reasoning and ultimately achievement (Aiello-Nicosia, Sperandeo-Mineo & Valenza, 1984; Jones, 1983; Lawrence, 1975). This could be the reason why the other camp of scholars argues against teaching process skills to students. Therefore, there is need to equip educators at all levels of education with required science process skills and viable strategies they can employ to teach learners. It is from this realization that acquisition of science process skills has been made one of the major goals and urgent concerns of teacher preparation programmes across the globe. In some countries like Turkey and United States of America, this is made explicit in educational or curriculum documents or while this is not the case in others.

Finally, as indicated through this chapter knowledge gaps have been identified owing to research methodologies, study contexts, lack of triangulation, inadequate research instruments, inability to show use and extent to which particular SPS were used. Generally, none of the studies reviewed specifically looked at the use of SPS by learners in chemistry 5124 practical activities in the Zambian context. Subsequently, the current study identified the following main knowledge gaps; to establish learners' views on use of SPS chemistry 5124 practical activities, to identify SPS learners use to conduct chemistry 5124 practical activities, to assess the extent to which learners use SPS to conduct chemistry 5124 practical activities, and to establish the relationship between learners' views on use of SPS and the SPS learners use to conduct chemistry 5124 practical activities in secondary schools of Kitwe district in Zambia.

2. 7 Chapter summary

In this chapter, literature has reviewed what science process skills are, their application to the learning of chemistry as well as their historical overview. Studies conducted on SPS both across the globe and Zambia in particular have also been reviewed. It has been observed that quite a number of studies have been done across the globe, with only a handful of studies particularly on SPS have been conducted in Zambia. In addition, the teaching of SPS in schools has been reviewed. Consequently, knowledge gaps were identified based on the literature reviewed and these pointed to research objectives of the present study. The next chapter describes the methodology of the study.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Overview

This chapter presents research methodology. It describes the philosophical underpinning and approach which guided the study, and research design. Additionally, it describes the study site, study population, study sample and sampling techniques. It further looks at data collection instruments, and their reliability and validity. It ends by looking at data collection and analysis procedures.

3.2 Philosophical underpinning and approach of the study

The study was underpinned by pragmatism. In this worldview, researchers are free to focus on the research problem and use all approaches available to understand the problem, instead of focusing on methods (Creswell, 2014). A wide range of scholars like Patton (1990), Tashakkori and Teddlie (1998) and Morgan (2007) among others argue that pragmatism is useful in social science researches as it helps to focus attention on the research problem as well as use pluralistic approaches to derive knowledge about the problem. Thus, pragmatism was used as a philosophical underpinning as it opens the door to multiple methods, different worldviews, different assumptions, and various forms of data collection, analysis and so forth (Creswell, 2009). Consequently, a mixed methods approach was used in this study in order to gain more insight and provide an expanded understanding, for neither qualitative nor quantitative approaches could have proven adequate by themselves to capture and clarify the research problem at hand. Ary, Jacobs and Razavieh (2009), and Creswell (2009) contended that this approach ensures that results produced in the study are more elaborate and provide complete explanation to the research problem than either of the two separate methods would provide. This approach was mainly used for complementarity and triangulation purposes. In terms of triangulation, the data collected by one method was checked by the other method. Ary et al. (2009) observed that triangulation helps to examine the convergence of evidence from different methods that study the same phenomenon.

With regard to complementarity, qualitative data helped in complementing quantitative data especially data that could not be collected by quantitative methods and vice versa.

3.3 Research design

The study employed a convergent mixed methods design. In this design, a single-phase approach is used to collect both qualitative and quantitative data, analyze them separately, and then compare results to see if the findings confirm or disconfirm each other (Creswell & Creswell, 2018). The current study relied so much on the key assumption of this design that both qualitative and quantitative data provide different types of information and together they yield results that should be the same. Hence, a convergent mixed methods design was used to investigate the issues involved in the study.

3.4 Study site

The study was conducted in government secondary schools of Kitwe district. The district has a total of 31 government secondary schools. There are 19 old established and 12 newly upgraded secondary schools, which are distributed across the district. The study targeted four secondary schools with a mixed gender of learner enrolment in order to account for gender disparities.

3.5 Study population

The population consisted of all grade 12 internal learners of chemistry 5124 in government secondary schools of Kitwe district, as these were prospective candidates for chemistry 5124 final examinations. The schools had about 1400 grade twelve learners registered for 2019 final examinations.

3.6 Study sample

The sample size involved in the study was 303 learners, as was determined by Bartlett, Kotrlik and Higgins' (2001) formula for determining minimum sample size for a given population size. The confidence interval used was 95% leaving a margin of error to 0.05.

3.6.1 Sample characteristics

i. Learners

These were grade 12 internal pupils who at the time of data collection had learnt chemistry 5124 for more than two years and were being prepared for final examinations. It was assumed that these pupils have had acquired sufficient SPS to carry out chemistry 5124 practical activities in an effective and efficient manner.

ii. Demographic information

The gender and age of learners at the time of data collection are presented here in order to account for such characteristics in the study. Figure 3 shows the distribution of learners' gender who took part in a survey.

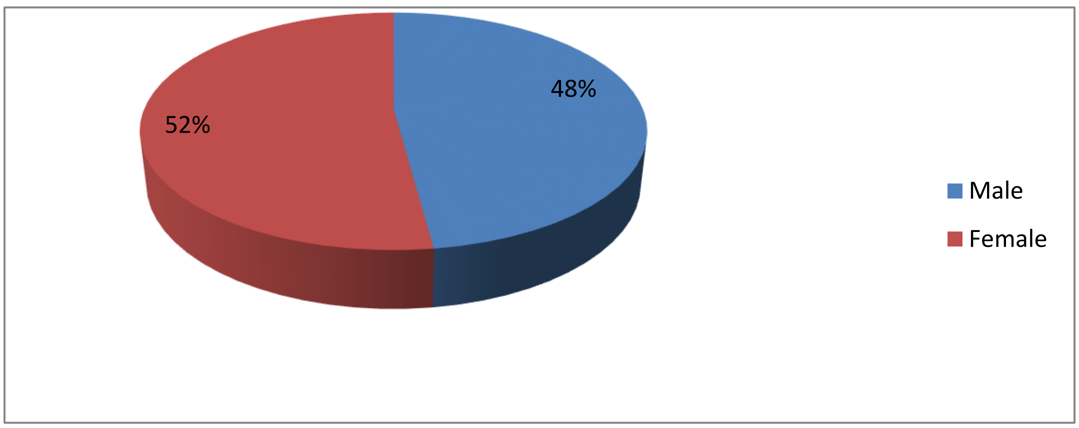


Figure 3: Gender distribution of learners.

Figure 3 indicates that there were more female than male learners who participated in the study survey despite the discrepancy in percentages being insignificant. The following is Figure 4 indicating age distribution of learners who participated in the survey.

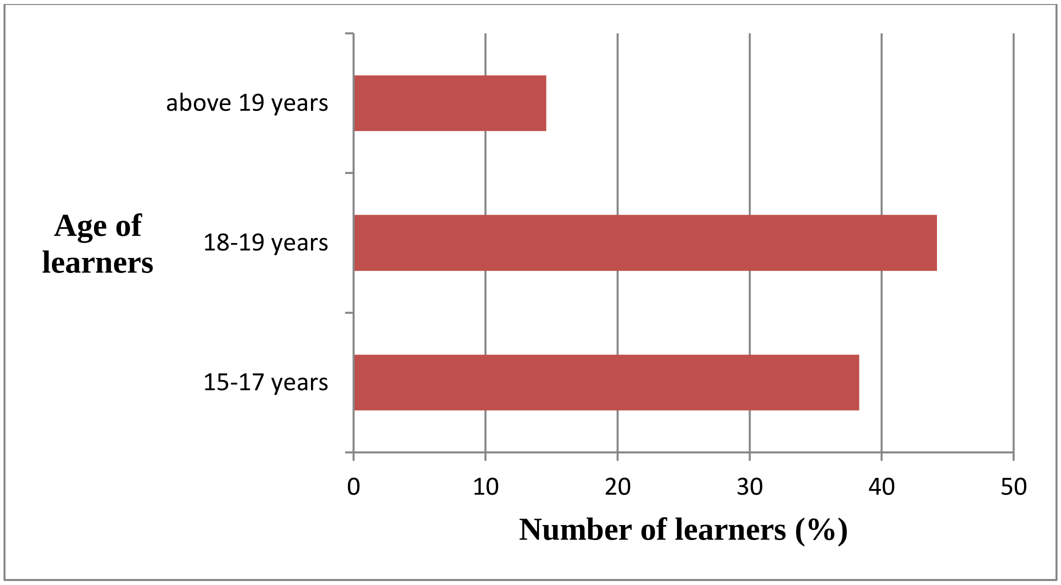


Figure 4: Age ranges of learners

Figure 4 show that the average age-range of learners who participated in the study survey was 18-19 years. This means that there were more learners aged 18-19 years who participated in the study.

3.7 Sampling techniques

Both probability and non-probability sampling procedures were used in this study. Firstly, the district was divided into four regions in order to account for social and economic disparities among participants (Aydogdu, 2017). Then one school was purposively selected from each region. The selection criteria were based on schools' recent performance in science 5124, type of school (only co-gender schools were considered), and availability of laboratories, equipment and resources to facilitate practical activities. Denscombe (2003) indicated that purposive sampling involves selecting participants with a specific purpose in mind, and that purpose reflects the particular qualities of the people or events chosen and their relevance to the topic of the investigation. Further, systematic sampling was used to select learners to participate in the study. This was achieved by the following formula,

"$f = \frac{\mathbf{N}}{\mathbf{n}}$, where f is the frequency interval, N is the total number of the wider population, n is the required number in the study sample" (Cohen et al., 2002, p.100).

Systematic sampling is one of the probability sampling techniques which involve selecting an initial point on the list of names of the target population by random process and then every n^{th} number on the list is selected (Struwig & Stead, 2001). This ensured that all grade 12 learners in selected schools had equal chances of being picked to participate in the survey; as such the total sample picked was a representative of the population. Besides, 12 learners for each school were selected using simple random sampling (from those who participated in the survey) in order to be observed in Chemistry practical activities. This number of learners for practical activities was sufficient due to the nature of data which was collected by this method, as well as ensured efficiency in terms of resources used in the study. Consequently, this helped the researcher also to effectively manage the group and focus all the limited resources and time to the groups in order to obtain rich and trustworthy data. The same learners who participated in practical activities took part in focus group discussion. Whereby, after each practical activity learners were divided into two groups to take part in focus group discussion which was facilitated by the researcher.

3.8 Data collection instruments

Learner questionnaire (LQ), observation schedule (OS) and focus group discussion guide (FGDG) were used for data collection (refer to Appendices A, B & D). Different data collection methods were used to ensure data triangulation (Plack, 2005). The following sub-sections give a brief description of data collection instruments.

3.8.1 Learner questionnaire

This instrument had three parts. First part of the instrument sought demographic data of learner. The second and third parts of the questionnaire was used to collect views of learners on use of SPS, practical opportunities and difficulties related to SPS use in chemistry practical activities respectively.

3.8. 2 Observation schedule

This instrument was used to determine the SPS learners used in actual Chemistry 5124 practical activities. Learners were subjected to a set of practical instructions called science process skills assessment instructions, SPSAI (refer to Appendix C). The OS was used to record observations while learners were carrying out SPSAI. The OS had three parts; the first part sought demographic data of learner and part two had columns and rows for recording learner arbitrary identify and SPS they used to conduct activities with their performance rated against the five-point Likert scale. Part three had columns for indicating difficulties which each learner experienced when conducting practical activities.

3.8. 3 Focus group discussion guide

This instrument was used to obtain views of learners on science process skills for chemistry 5124 practical activities. It contained similar features and questions as those in questionnaire and observation schedule for it was mainly used for triangulation and complementarity purposes as mentioned earlier. In addition to the aforementioned instruments, a camera and audio recorder were used to record events during practical activities and focus group discussion sessions respectively, this ultimately was intended for further data analysis and reference.

3.9 Reliability and Validity of the Instruments

There was wide consultation from experts during formation of research instruments. All the instruments were developed by the researcher and validated by experts from the department of Mathematics and Science education of the University of Zambia. The instruments were also subjected to Cronbach's Alpha reliability test. The reliability coefficients of 0.7 (1 d. p) were obtained for both LQ and OS. This showed that the instruments were suitable for the study (Reynaldo & Santos, 1999). Thereafter, the instruments were piloted in order to check for gaps in questions and ensure clarity of items therein.

3.10 Data collection procedure

To start with, permission for data collection in secondary schools of Kitwe district was sought with relevant authorities in advance. Permission was sought from the district education board secretary then school head teachers or deputy head teachers and head of departments (HODs)-natural sciences to conduct a study in their schools. The actual data collection was preceded by a pilot study. The pilot study was conducted in one of the co-gender secondary schools within the district and with a random sample of ten grade 12 learners. This process helped the researcher to check for gaps and ensure clarity of issues in research instruments. The school used for a pilot study was not considered during actual data collection, so as to remove biasness from the results. During data collection, the researcher administered questionnaires to 303 learners in schools. This was followed by observations of learners carrying out chemistry 5124 practical activities. The researcher with the help of HODs and science teachers administered practical activities to learners. The equipment, apparatus and materials for the practical activities were supplied by the schools through Natural Science departments. The researcher observed 48 learners (12 learners per school) while they carried out practical activities. During observations, learners were given SPSAI, while the researcher used an OS to record observations based on learners' use of SPS and related difficulties while they carried out practical tasks. Thereafter, focus group discussions were conducted to discuss learners' views and their experience during practical activities. As such, the same participants from practical observations were divided into two groups in order to take part in the focus group discussions.

3.11 Data analysis procedure

Qualitative data were analyzed through establishment of common themes. This was achieved by transcribing raw data, organizing and coding it into themes, then interrelating and interpreting these themes to draw meanings with respect to research objectives (Creswell, 2009). Some of the data collected by qualitative method was quantified and analyzed together with the quantitative data in order to answer research questions accordingly. Quantitative data were analyzed by both descriptive and inferential statistics. Particularly, frequencies, t- and Chi-square tests generated by statistical package for social science (SPSS) software were used to analyze quantitative data. Nonetheless, the raw statistical output of SPSS was not indicated but only the main statistics were considered. Besides, pictures and recordings of events in the study were used to offer in-depth analysis of data collected. Both qualitative and quantitative data were analyzed concurrently as necessitated by the research design.

3.12 Chapter summary

The chapter started by discussing pragmatism as the philosophical underpinning of the study. This world view helped to focus attention on the research problem as well as use pluralistic approaches to derive knowledge about the problem. Consequently, a convergent mixed methods design was used due to its flexibility in data collection, analysis and discussion. The chapter also described study site, population, sample and sampling procedures. It further went on to describe research instruments (questionnaire, observation schedule and focus group discussion guide) and their reliability and validity. Data collection and analysis procedures were also explained in this chapter. The findings obtained in this study are presented in the next chapter.

CHAPTER 4

PRESENTATION OF FINDINGS

4.1 Overview

In order to answer research questions, data were collected from learners using various research instruments as indicated in the previous chapter. This chapter presents study findings according to research questions and instruments.

4.2 Views on use of science process skills in chemistry 5124 practical activities

The first research question was: **“What are the learners' views on the use of SPS in chemistry 5124 practical activities?”**, in order to answer this question data was collected from learners using questionnaires and focus group discussion guides.

4.2.1 Findings from learner questionnaires

Before learners indicated the SPS they used in chemistry practical activities, they were required to indicate what they understood by SPS and whether they were exposed to practical opportunities where they could use SPS. As such findings are presented in the same order.

4.2.1.1 Learners’ understanding of science process skills

Learners’ responses on what they understood by SPS were analyzed and rated using the scale of unsatisfactory, satisfactory, good and very good. Then such results were subjected to descriptive statistics. Frequencies of responses are as shown in Table 2.

Table 2: Learners' understanding of science process skills

S.No.	Learners' understanding of SPS	Frequency	Percentage (%)
1	Unsatisfactory	153	50.5
2	Satisfactory	53	17.5
3	Good	7	2.3
4	Very good	9	3
5	No response	81	26.7
	Total	303	100

N=303

Table 2 indicates that over 50% of learners gave unsatisfactory responses on the understanding of SPS, with about 27% of learners not indicating their responses. This implies that learners did not understand what science process skills are. The following are examples of their responses where they gave unsatisfactory responses.

> *Leaner D of school SW: "Science process skills are* skills we use to learn science."

Notice that the response by learner D was too vague. The learner only tried to play around with words in the question and this simply indicated lack of understanding of what SPS are. Some learners got their responses from online sources as indicated in the following example:

Leaner H of school SE: "They include observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting and communicating."

This response was right; however, this learner actually just copied her answer from one of online sources. This was an indication that learners didn't really understand what SPS are. Some of the learners did not hide their ignorance about the subject and indicated accordingly while others did not attempt to write anything. An example is as indicated by the verbatim below.

Learner I of school NW: "I don't know these science process skills; it is my first time to hear about them."

Overall this meant that learners did not understand (did not know) what science process skills are.

4.2.1.2 Practical opportunities in chemistry

On this item the question was asked to determine whether learners were given practical opportunities, with responses limited to yes or no. The following were the results shown in Table 3,

Table 3: Learners' responses on practical opportunities

S.NO.	Given practical opportunities…	Frequency	Percentage (%)
1	Yes	54	17.8
2	No	243	80.2
3	No response	6	2
	Total	303	100

N= 303

Table 3 indicates that less than 20% of learners were given while about 80% were not given practical opportunities in chemistry. Only 2% of learners did not indicate their responses. This generally shows that learners were not given practical opportunities in chemistry by the time of research. However, about 18% of learners were in affirmation to having been given practical opportunities, and this suggests that small number of learners were given practical opportunities where they used SPS.

4.2.1.3 Use of science process skills in chemistry 5124 practical activities

Here learners were asked to indicate the SPS they used in chemistry 5124 practical activities using a 5-point Likert scale of strongly agree to strongly disagree. Data on this item were then put into two categories (those which indicated they used SPS and those which showed otherwise) and then such responses were analyzed by descriptive statistics, frequencies of results are shown in Figure 5.

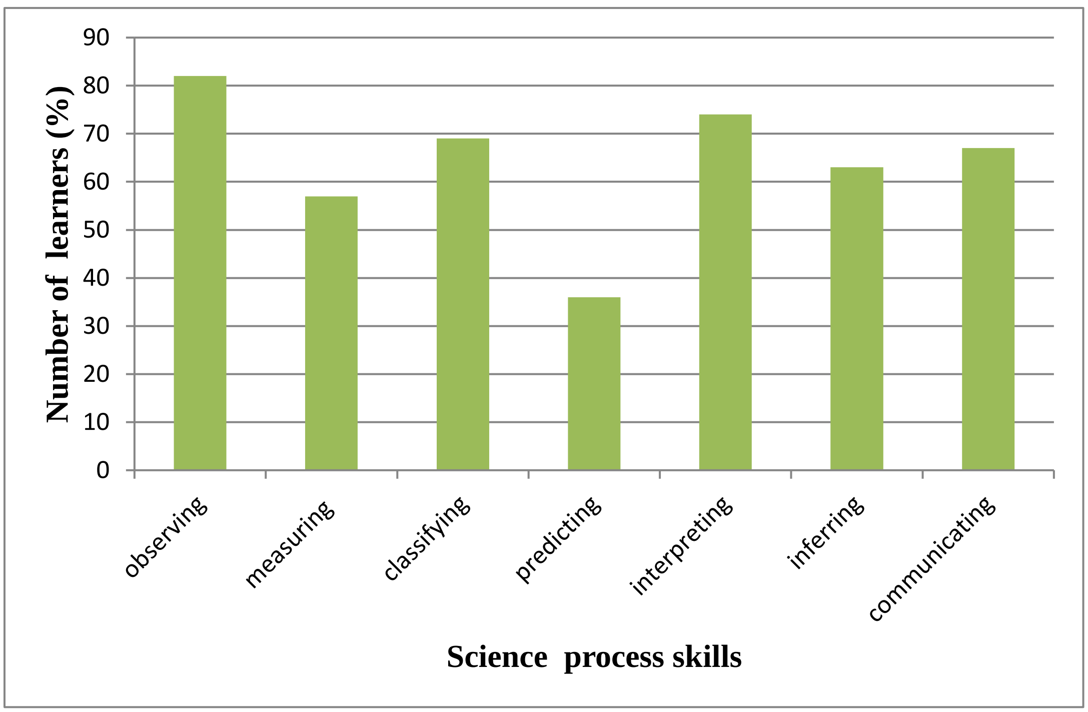


Figure 5: Distribution of responses on use of SPS

The results in Figure 5 show that more than 57% of learners indicated that they used observing, measuring, classifying, interpreting, inferring and communicating skills in chemistry practical activities. It also shows that more than 74% of learners indicated that they did not use predicting skill in the said activities. This means learners used all the aforementioned skills, except predicting in chemistry practical activities.

4.2. 2 Findings from focus group discussion guides

In this regard, views of learners on use of SPS in chemistry practical activities were collected from eight focus group discussions. The question required learners to indicate the SPS which they used in chemistry practical activities. The scale of agree, not sure and disagree was used to categorize and record learner responses. Table 4 shows frequencies of responses for each respective SPS.

Table 4: Learners' group responses on use of SPS in chemistry practical activities

S.No.	SPS used in Chemistry practical activities	Frequency		
		Agreed	Not sure	Disagreed
1	Observing	7	1	0
2	Measuring	8	0	0
3	Classifying	6	0	2
4	Predicting	3	2	3
5	Interpreting	4	3	1
6	Inferring	3	0	5
7	Communicating	8	0	0

N=8

Table 4 shows that over five groups of learners agreed that they used observing, measuring, classifying and communicating whereas more than four groups disagreed that they did not use inferring in chemistry practical activities. This means learners used all the aforementioned skills except inferring in chemistry practical activities. With regard to predicting skill; three groups agreed while three disagreed (with two not sure) to use predicting in chemistry practical activities. Thus, it was not clear whether learners used predicting skill or not in chemistry practical activities in this regard.

4.3 Science process skills learners used to conduct chemistry 5124 practical activities

The second research question was: "**What SPS do learners use to conduct chemistry 5124 practical activities?**", In order to answer this question, learners were observed while carrying out SPSAI in four different schools. Observation schedules were used to record the SPS learners used and those they did not use to conduct chemistry practical activities. Here each learner was observed undertaking an activity for each SPS and their performance recorded accordingly. Figure 6 shows the frequency of learners' scores on use of each SPS in chemistry practical activities.

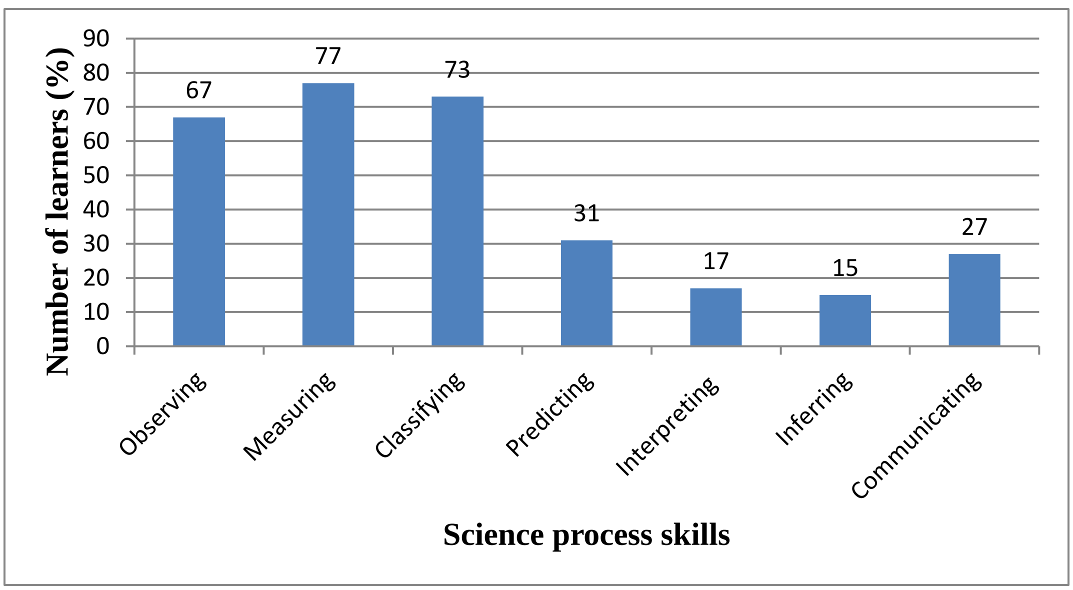


Figure 6: SPS learners used to conduct chemistry practical activities

Figure 6 shows that, on one hand over 65% of learners used observing, measuring and classifying while on the other, more than 70% of learners did not use predicting, interpreting, inferring, and communicating to conduct Chemistry practical activities.

This indicates that learners used observing, measuring and classifying, but did not use predicting, interpreting, inferring and communicating to conduct chemistry practical activities. For instance, one of the learners was observed attempting to take the volume of an acid with accuracy as shown in Figure 7.

Figure 7: An attempt to get accurate volume of the acid by the learner

This shows that the learner was aware of parallax errors associated with measuring in this regard. Hence, she avoided such errors by taking her reading from the meniscus of the acid at an appropriate angle depicted in Figure 7. This is an indication that the learner used measuring skill in an effective manner to conduct a chemistry practical activity.

A different illustration is where another learner was observed having made incorrect conclusion as highlighted in the extract shown in Figure 8.

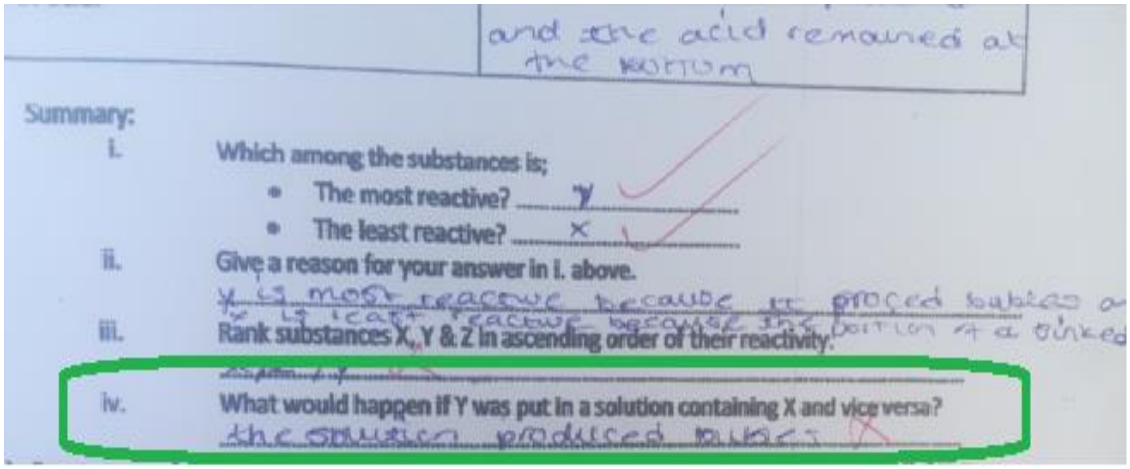


Figure 8: Absence of inferring skill

Here the learner was expected to use inferring skill to answer question (iv) encircled green, especially considering that he answered question (i) correctly. However, he failed to give the correct answer (did not make correct inference) despite having identified that Y was the most reactive metal and X least reactive metal among the metals given. Correct inference was supposed to be: If metal Y is more reactive than metal X then Y would displace X from its solution while no reaction would take place if X was put in a solution of a compound containing Y. Metal X would not displace metal Y from its solution because it is less reactive than Y. This indicates that the learner lacked inferring skill and so did not use it when carrying out chemistry practical activities.

4.4 Learners' level of use of science process skills in chemistry 5124 practical activities

The third research question was: **"To what level do learners use SPS to conduct chemistry practical activities?"** In order to answer this question, data was collected by observing learners carrying out SPSAI while the researcher used OS to record data. The level of use of SPS by learners was rated against the scale ranging from no attempt, unsatisfactory, satisfactory and good to very good. Figure 9 shows the frequencies of the level of use for each SPS.

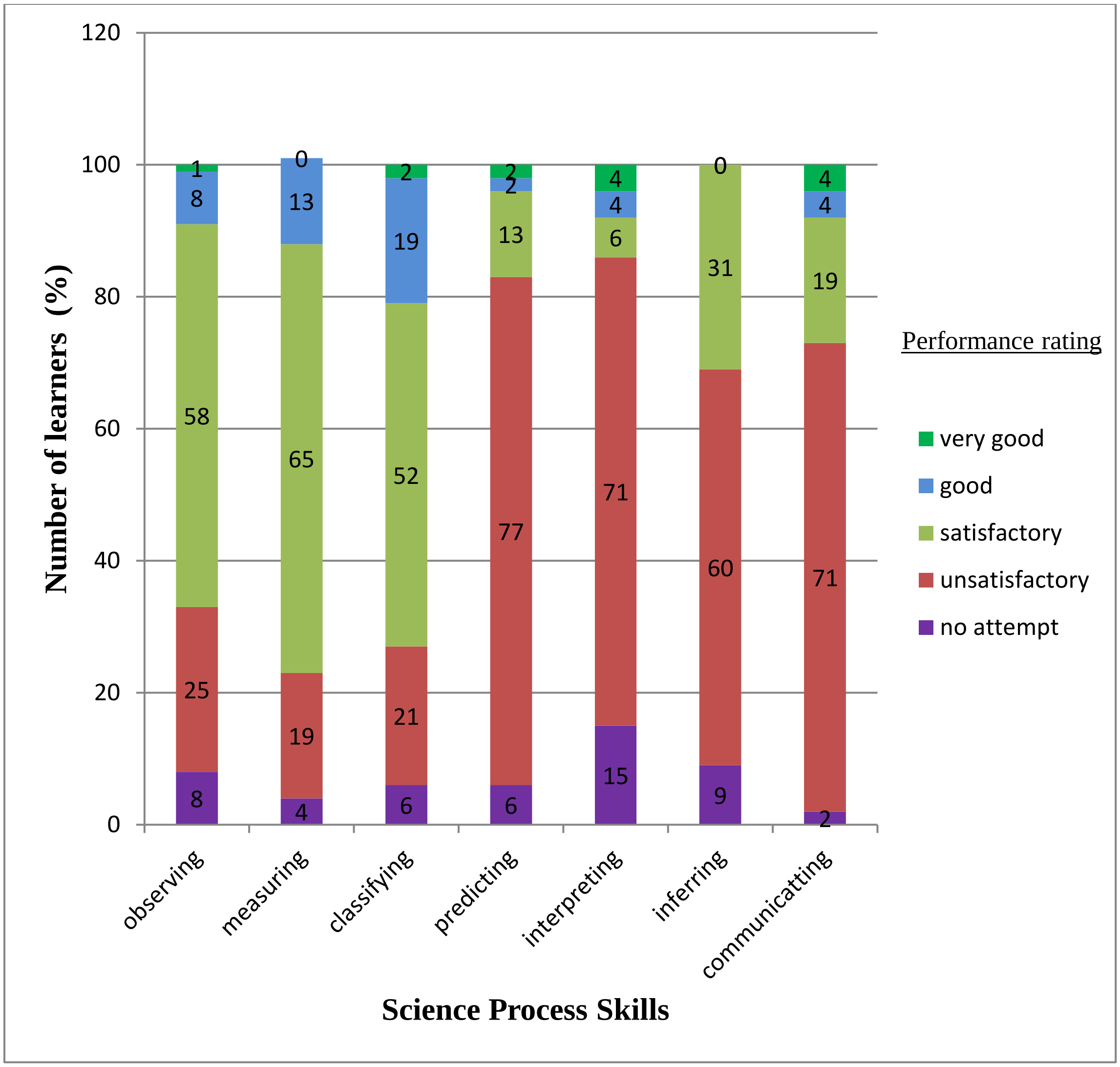


Figure 9: Learners' level of use of SPS

The results in Figure 9 indicates that learners used observing, measuring and classifying at satisfactory levels while the levels at which they used predicting, interpreting, inferring and communicating were unsatisfactory. As can be seen for instance most learners (more than 75%) performed at least fairly in measuring skill while most of them (more than 80%) did not perform fairly well in predicting skill in practical activities. Interpreting skill recorded the highest (15%) while communicating skill had the lowest (2%) number of learners who made no attempt to use these skills in given activities. Overall, this means that learners only used observing, measuring and classifying at least to the required level but did not use the rest of SPS up to the minimal required level when carrying out chemistry practical activities.

4.4.1 Difficulties experienced by learners in chemistry 5124 practical activities

Two research instruments (OS and FGDG) were mainly used to establish difficulties learners faced with respect to use of each SPS in chemistry practical activities.

4.4.1.1 Findings from Observation schedules

Part three of observation schedule was used to establish difficulties on process skills components learners experienced when carrying out chemistry practical activities. According to observations, learners exhibited a range of difficulties in chemistry practical activities as follows:

i. Failure to correctly write or communicate observations in an acceptable manner. For instance, Figure 10 depicts learner F at school NE experiencing difficulties in recording observations in one of the given activities.

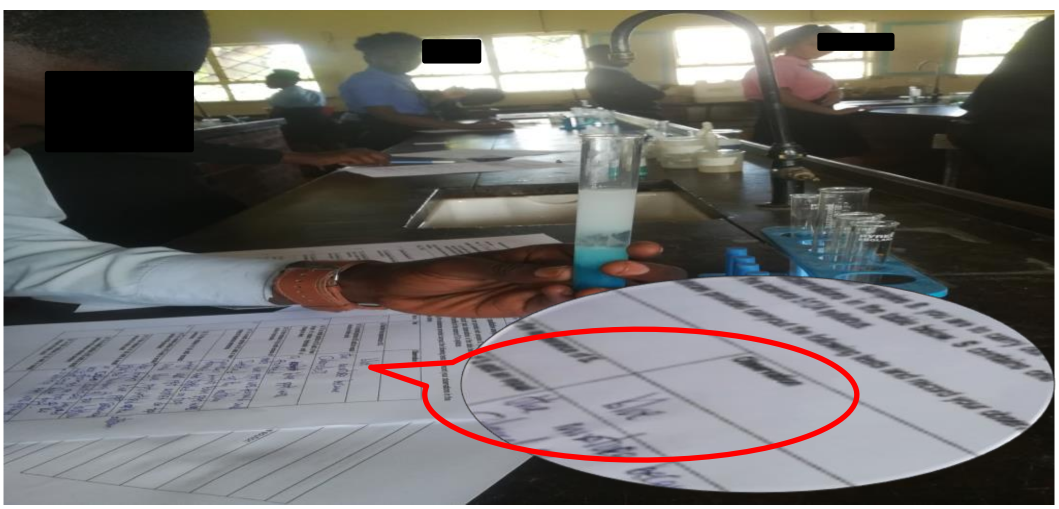


Figure 10: Incorrect way of communicating observation

As indicated in Figure 10, the learner failed to communicate his observations in an acceptable manner. Here the learner was required to describe the appearance of sample S as a ‘blue solution’, because the color and the state of the sample were very cardinal in this regard. Instead the learner only wrote ‘blue’. This means that the learner had insufficient communicating skill to write his observations in a required way.

ii. Failure to write correct chemical symbols and formulae. In one of the activities (qualitative analysis); having carried out tests and made observations, learners were expected to identify a cation and an anion and eventually write the formula of the salt in solution S. The following extracts depicted in Figures 11 and 12 show some learners’ answers as observed in this regard:

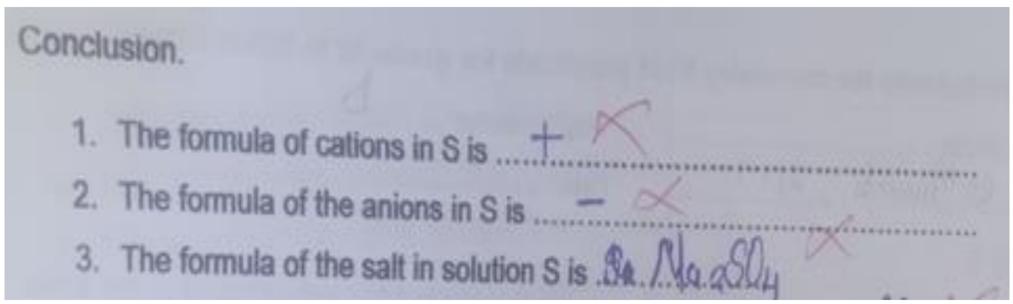


Figure 11: Lack of communicating skill

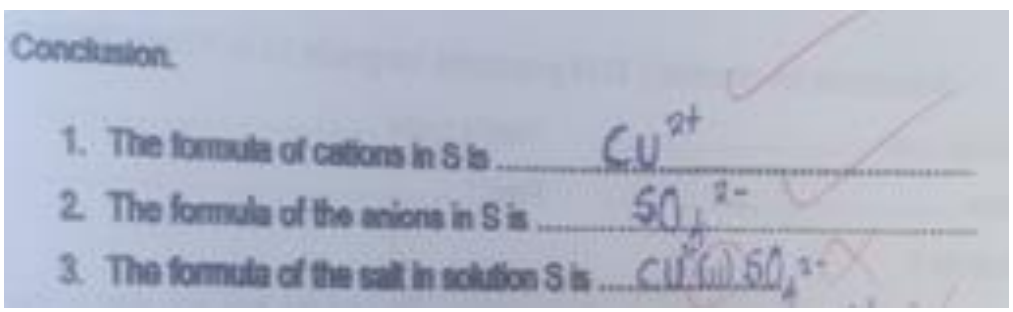
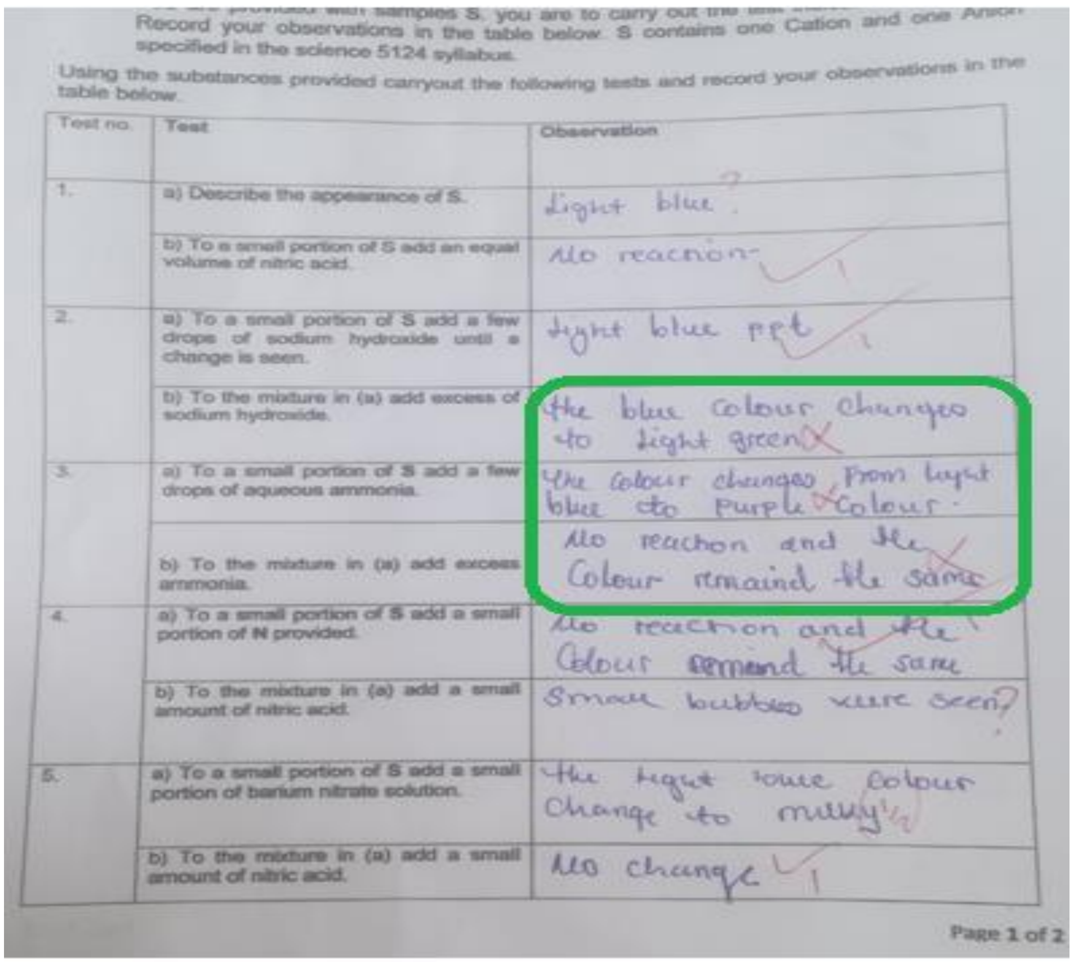


Figure 12: Inadequate communicating skill

In Figure 11, the learner only wrote positive (+) and negative (-) symbols as his answers for conclusion 1 and 2 respectively. However, expected answers for conclusion 1 and 2 were as shown in Figure 12, Cu^{2+} & SO_4^{2-} respectively. This showed that the learner lacked communicating skill with regard to use of chemical symbols. In Figure 12, the learner got conclusion 1 and 2 correct but failed to write the correct chemical formula of a salt present in the solution, as shown by his answer in conclusion 3. The correct formula was supposed to be $CuSO_4$. This shows that the learner had inadequate communicating skill with regard to use of chemical formulae.

iii. Failure to make required observations. Some learners failed to make correct observations such as expected color changes and physical states of substances when carrying out practical activities. For instance, one of the learners was observed experiencing difficulties in observing skill as shown in column three for observations of test numbers 2b, 3a and 3b, highlighted in green, in Figure 13.



Record your observations in the table below. S contains one Cation and one Anion specified in the science 5124 syllabus.

Using the substances provided carryout the following tests and record your observations in the table below.

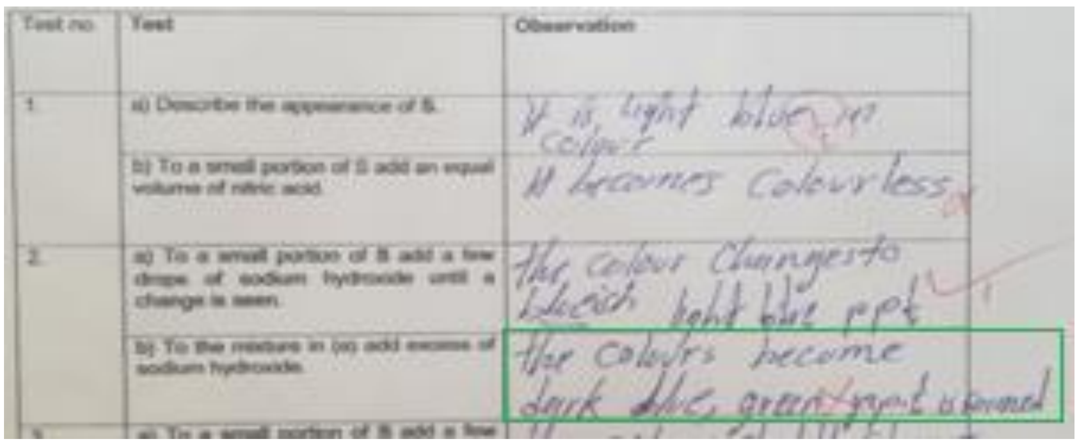
Test no.	Test	Observation
1.	a) Describe the appearance of S.	Light blue ?
	b) To a small portion of S add an equal volume of nitric acid.	No reaction ✓ 1
2.	a) To a small portion of S add a few drops of sodium hydroxide until a change is seen.	light blue ppt ✓ 1
	b) To the mixture in (a) add excess of sodium hydroxide.	the blue colour changes to light green ✗
3.	a) To a small portion of S add a few drops of aqueous ammonia.	the colour changes from light blue to purple ✗ colour.
	b) To the mixture in (a) add excess ammonia.	No reaction and the Colour remaind the same ✗
4.	a) To a small portion of S add a small portion of N provided.	No reaction and the Colour remand the same ✓ 1
	b) To the mixture in (a) add a small amount of nitric acid.	Small bubbles were seen ?
5.	a) To a small portion of S add a small portion of barium nitrate solution.	the light blue colour change to milky ½
	b) To the mixture in (a) add a small amount of nitric acid.	No change ✓ 1

Page 1 of 2

Figure 13: Difficulty in observing skill.

Here learners were expected to observe the following: adding excess sodium hydroxide to mixture, test number 2b, yielded insoluble blue precipitate; adding few drops of aqueous ammonia to S formed blue precipitate; and adding excess ammonia to S produced a dark blue solution. However, as illustrated in Figure 13 the learner failed to make required observation an indication that he had inadequate observing skill. The observe skill could be said to be inadequate because in some cases, like tests numbers 1b and 2a, the learner made correct observations.

Another example where a certain learner exhibited difficulties in observing skill is illustrated in the following extract, Figure 14.

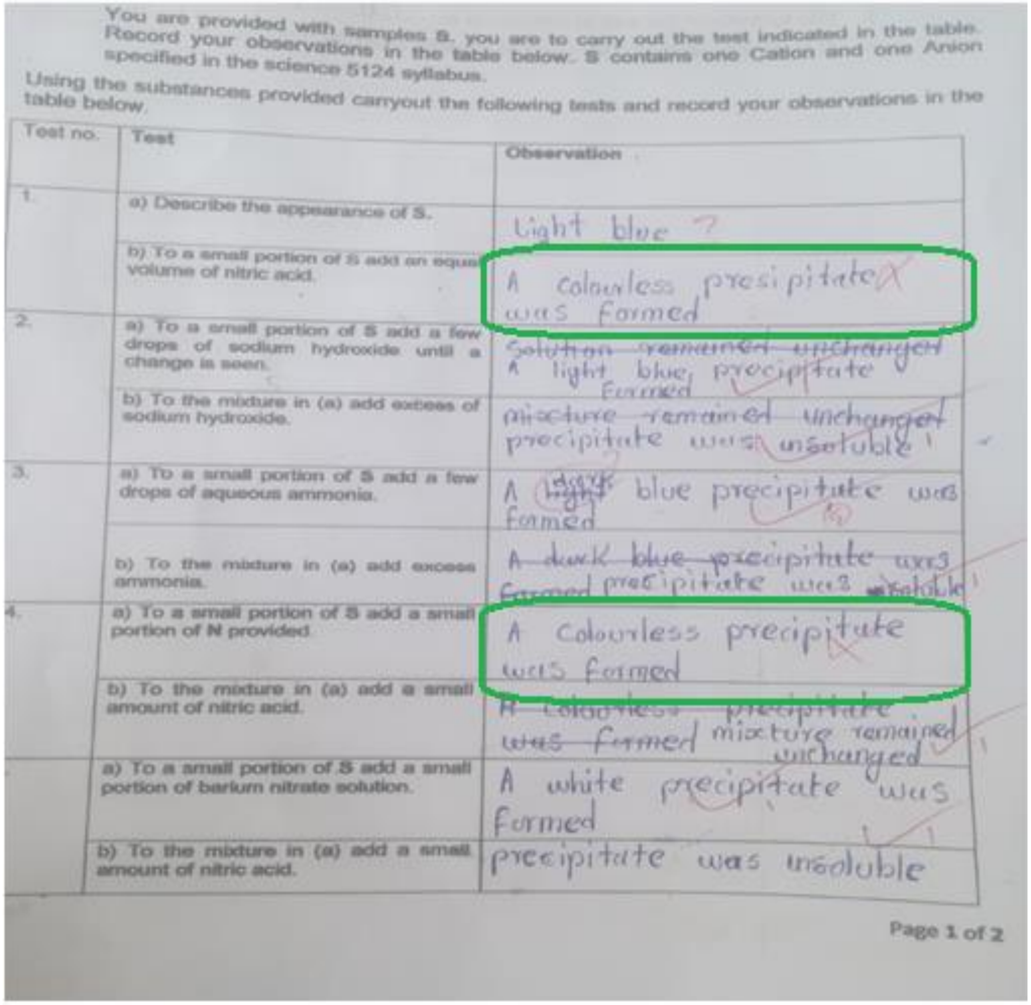


Test no	Test	Observation
1	a) Describe the appearance of S.	It is light blue in colour
	b) To a small portion of S add an equal volume of nitric acid.	It becomes Colourless
2	a) To a small portion of S add a few drops of sodium hydroxide until a change is seen.	the colour Changes to bluish light blue ppt
	b) To the mixture in (a) add excess of sodium hydroxide.	the colours become dark blue, green ppt is formed

Figure 14: Inadequacy in observing skill

On this activity, test number 2b as shown in Figure 14, learners were expected to observe that adding excess sodium hydroxide to mixture in (2a) produced insoluble blue precipitate. However, some learners did not only fail to make required observations on solubility of precipitate when excess reagents were added but also gave range of colors (as the extract in Figure 14 indicates) which is even unacceptable as only one color could be seen in practical activities. These instances indicate that learners' observing skills were inadequate.

iv. Failure to differentiate states of substances. For example, some learners were observed confusing physical states of substances as shown in Figure 15 in one of the learners' extracts.



You are provided with samples S. you are to carry out the test indicated in the table. Record your observations in the table below. S contains one Cation and one Anion specified in the science 5124 syllabus.

Using the substances provided carryout the following tests and record your observations in the table below.

Test no.	Test	Observation
1.	a) Describe the appearance of S.	Light blue ?
	b) To a small portion of S add an equal volume of nitric acid.	A colourless presipitate was formed
2.	a) To a small portion of S add a few drops of sodium hydroxide until a change is seen.	~~Solution remained unchanged~~ A light blue precipitate formed
	b) To the mixture in (a) add excess of sodium hydroxide.	~~mixture remained unchanged~~ precipitate was insoluble
3.	a) To a small portion of S add a few drops of aqueous ammonia.	A dark ~~light~~ blue precipitate was formed
	b) To the mixture in (a) add excess ammonia.	~~A dark blue precipitate was formed~~ precipitate was soluble
4.	a) To a small portion of S add a small portion of N provided.	A Colourless precipitate was formed
	b) To the mixture in (a) add a small amount of nitric acid.	~~A colourless precipitate was formed~~ mixture remained unchanged
	a) To a small portion of S add a small portion of barium nitrate solution.	A white precipitate was formed
	b) To the mixture in (a) add a small amount of nitric acid.	precipitate was insoluble

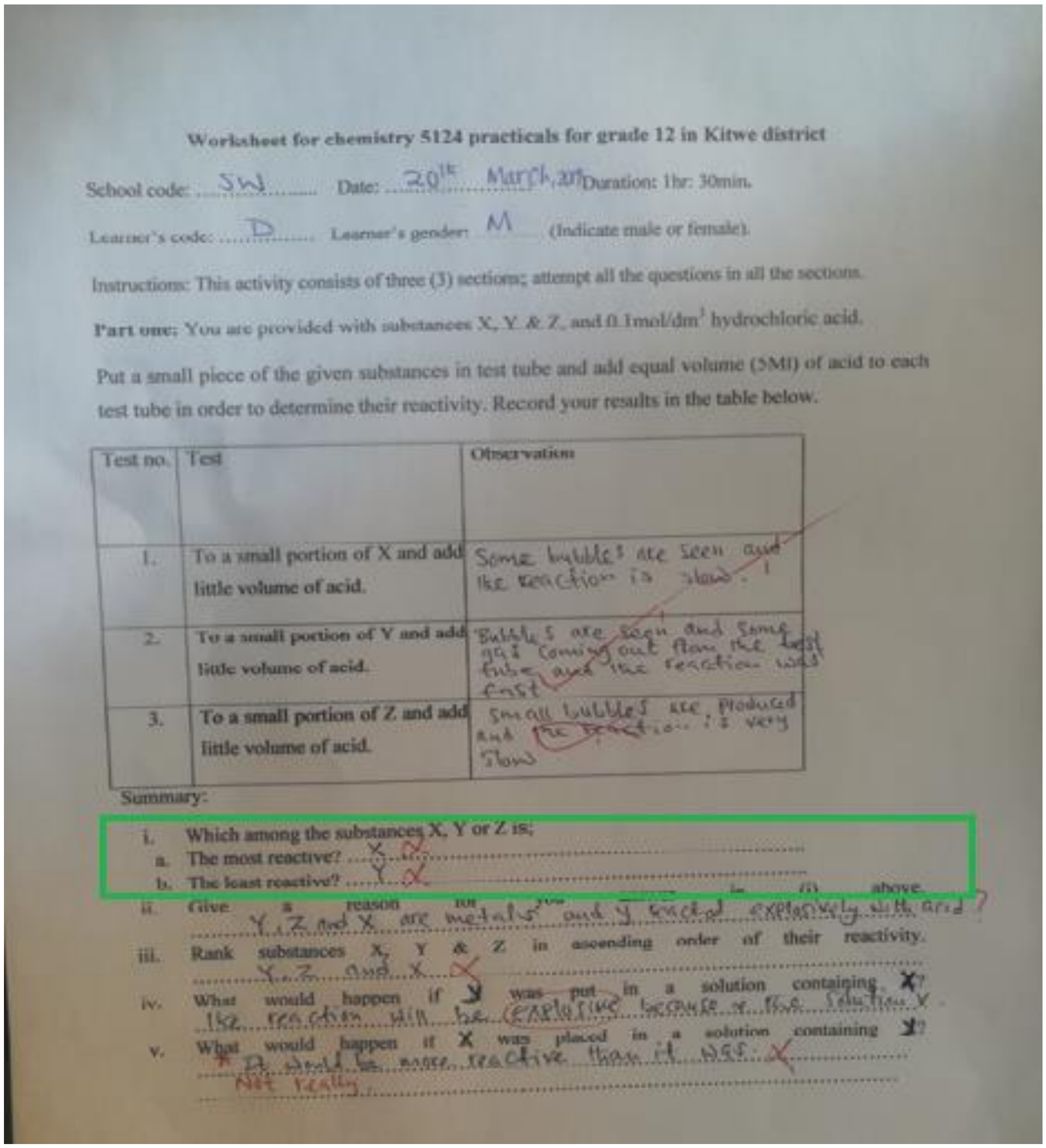
Page 1 of 2

Figure 15: Difficulty in differentiating physical states of substances

On observations for Tests number 1b and 4a, learners were expected to observe that adding nitric acid and solution N to sample S produced a clear blue solution in both instances. Instead the learner as highlighted in green, in Figure 15, indicated that a colorless precipitate was formed when nitric acid and solution N were added to S respectively. This was an indication that the learner confused clear solutions with precipitates or simply solutions with mixtures. This means learners lacked classifying skill and consequently experienced difficulties in using it.

v. Failure to draw conclusions from observations and relating their observations to the scientific theories. This means learners had difficulties in inferring skill (refer to Figure 8).

vi. Failure to interpret results from observation(s). The following is a manuscript for learner D of school SW who exhibited lack of interpreting skill in one of the activities (question i, highlighted in green) as indicated in Figure 16.



Worksheet for chemistry 5124 practicals for grade 12 in Kitwe district

School code: SW Date: 20th March, 2019 Duration: 1hr: 30min.

Learner's code: D Learner's gender: M (Indicate male or female).

Instructions: This activity consists of three (3) sections; attempt all the questions in all the sections.

Part one: You are provided with substances X, Y & Z, and 0.1mol/dm³ hydrochloric acid.

Put a small piece of the given substances in test tube and add equal volume (5Ml) of acid to each test tube in order to determine their reactivity. Record your results in the table below.

Test no.	Test	Observation
1.	To a small portion of X and add little volume of acid.	Some bubbles are seen and the reaction is slow.
2.	To a small portion of Y and add little volume of acid.	Bubbles are seen and some gas coming out from the test tube and the reaction was fast
3.	To a small portion of Z and add little volume of acid.	Small bubbles are produced and the reaction is very slow

Summary:

i. Which among the substances X, Y or Z is;
a. The most reactive? X
b. The least reactive? Y
ii. Give a reason for your answer in (i) above.
Y, Z and X are metals and Y reacted explosively with acid ?
iii. Rank substances X, Y & Z in ascending order of their reactivity.
Y, Z and X
iv. What would happen if Y was put in a solution containing X?
the reaction will be explosive because of the solution Y
v. What would happen if X was placed in a solution containing Y?
* It would be more reactive than it was.
Not really

Figure 16: Difficulty in interpreting skill

In order to answer question (i), one needed to carry out test number 1 and 2, and based on observations in these tests come up with interpretations. Figure 17 illustrates reactions and expected observation for test number 1, 2 and 3 (that is reactions of metal X, Y & Z with acid) in given activities.

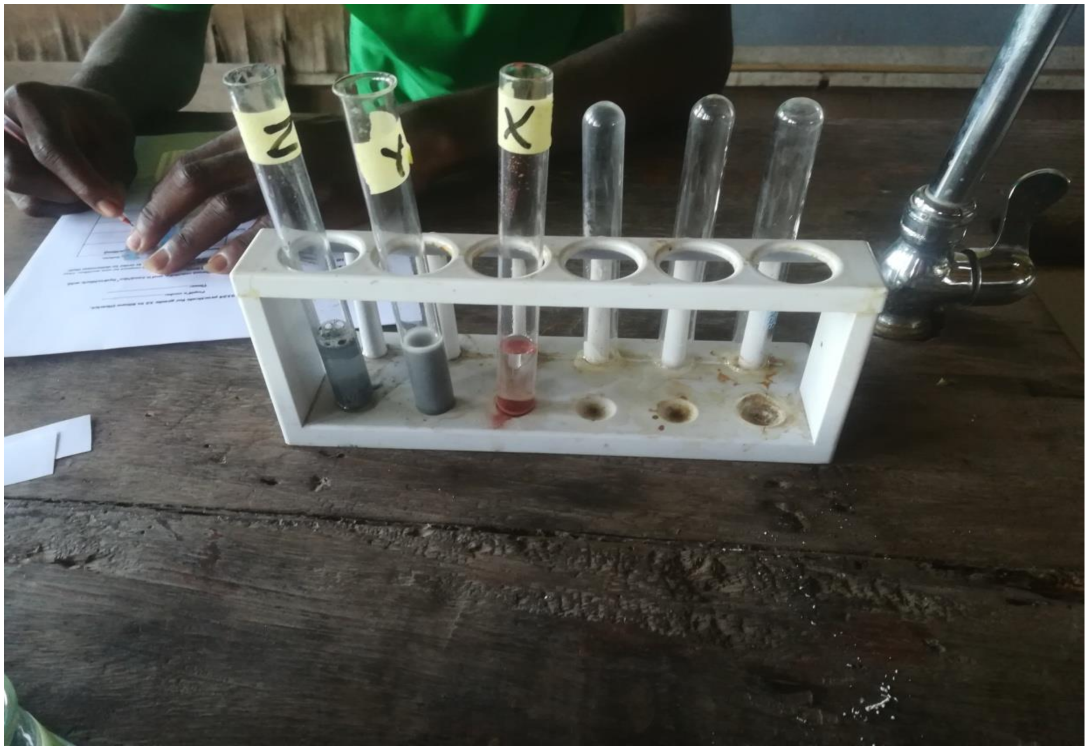


Figure 17: Reaction of metals

As illustrated, the reaction for X was very slow, Y was very vigorous and Z was moderately vigorous. It was expected that the learner would come up with correct interpretation, considering that he got the observations for test number 1 and 2 right as indicated in Figure 16. However, the learner failed to make a correct interpretation an indication that he lacked interpreting skill.

Finally, it can be noted that most learners had challenges related to use of SPS such as observing, classifying, inferring, interpreting data and communicating in chemistry 5124 practical activities as indicated in this section.

4.5.2.2 Findings from Focus group discussion guides

Focus group discussions were conducted to establish whether learners faced difficulties when using SPS in conducting chemistry practical activities and if so what these difficulties were. Learners indicated that they faced a range of difficulties when doing chemistry practical activities as follows:

i. Observing color changes of some reactions, especially in qualitative analysis. Learners indicated that it is very difficult to state the colors in some reactions. When asked how they found identifying characteristics or properties of substances, for example color or temperature of substances in practical activities. The following were some of the responses;

***Learner L of group 3**: "I find it hard to identify some colors because they are too difficult to know, and which color the teacher wants me to see in an experiment.*"

***Learner B of group 7**: "I can use a thermometer to know the temperature of a substance, I can also identify some colors but it is difficult to know colors of some substances which are mixed."*

This indicates that learners had inadequate observing skill for chemistry 5124 practical activities.

ii. Interpreting data or observations in some activities. When asked how they found explaining observations or attach meaning to data collected in a given chemistry practical activity. Learners indicated that they experienced difficulties in interpreting observations in some experiments. A typical example is where one of the learners answered;

***Learner A** of **group 5**: "I can finish all the steps in experiments like measuring, mixing substances…but answering ama questions ukufuma pali observation mpangile muli experiment ni problem imbi."*

***Translation**:* I can do all the steps in an experiment like measuring, mixing substances…but answering *questions based on the observations I made in an experiment is another problem.*

This showed that learners lacked interpreting skill.

iii. Drawing correct conclusion at the end of an experiment. Learners revealed that they had difficulties when it came to drawing conclusions in practical activities. This is illustrated in a group 2 conversation as follows:

***Researcher**: “*Are you able to draw reasonable conclusions based on your observations in chemistry practicals?”

***All learners:** “Yes!”(Shouted).*

***Researcher**: “how do you do it?”*

***Learner H**: “sir, in some experiments I can conclude but in some other experiments I don’t know how to conclude.”*

***Researcher**: “ok give me examples of those experiments where you know or do not know how to conclude.”*

***Learner H**: “but sir.” (Hesitatingly and went mute).*

***Learner L**: “To be honest with you, sir, we rarely do experiments and so I personally don’t know how to conclude...”*

This means learners lacked inferring skill for chemistry 5124 practical activities.

iv. Making predictions in experiments. Learners said they used predicting skill in practical activities as shown in the following discourse from group 3.

***Researcher:** “Do you state the outcome of a future occurrence based on your observations in chemistry practical activities?”*

***Learner E:** “What do you mean?”*

***Researcher**: “I mean, do you give a scientific guess on likely results of events before the chemistry experiment comes to an end?”*

***Learner J**: “I can predict just by guessing.”*

All learners agreed that they were able to predict. When probed further what they meant by ‘predicting’, it was found that they meant a mere guess not a scientific one. This indicates that learners lacked predicting skill for chemistry 5124 practical activities.

v. Communicating observations in an acceptable way, especially when demanded that chemical equations must be used for certain reactions. The following discourse illustrates responses of learners in group 1.

***Researcher**: “How do you find use of chemistry language, for example use of symbols, chemical formulae and numbers in chemistry activities?”*

***Learner C**: “I know how to use chemical symbols, formulas and numbers.”*

Then the researcher requested all those who also agreed that they used symbols, chemical formulae and numbers in chemistry activities to write down the chemical formula for copper (ii) sulfate.

Learner C: *Cu_2S_2.*
Learner F: *“Some chemical formulas are too complicated especially where two compounds are put together.”*

Learner A: *“the answer is Cu_2SO_4 or $CuSO_4$, am not sure.”*

Researcher: *“since you are uncertain on which answer is the correct one, can I give you a different question.”*
Learner A: *“yes sir”*
Researcher: *“I want you to write the formula for magnesium sulfate.”*
Learner A: *$MgSO_4$.*
Researcher: *“very good! but why did you fail to answer the first question correct?”*
Learner A: *“sometimes it’s confusing like to write numbers in chemical formulas.”*

It can be noted that learners faced difficulties in using chemical formula and numbers. The correct answer for copper sulfate is the second one ($CuSO_4$) given by learner A. However, being uncertain in her answer was an indication that she had inadequacies in writing chemical formulae of some chemical substances. This showed that learners had insufficient communicating skill with regard to use chemistry language in chemistry 5124 practical activities.

Finally, it can be observed that learners experienced difficulties in observing, interpreting, inferring, predicting and communicating skills in chemistry 5124 practical activities.

4.5 The relationship between views of learners on use of science process skills and the science process skills learners used in chemistry 5124 practical activities

The fourth research question was: **“What is the relationship between learners’ views on the use of SPS and the SPS learners use to conduct chemistry 5124 practical**

activities?” This question was answered using hypothesis. In order to test the hypothesis a Chi-square test was conducted; to achieve this, some data from questionnaires were transformed into forms (similar forms) which could be related with that obtained from observation schedules. The following hypotheses were tested at 95% confidence level (i.e. α=0.05, significance level).

> **H_0**: There is no relationship between learners’ views on the use of science process skills and the science process skills learners use to conduct chemistry 5124 practical activities.
>
> **H_1**: There is a relationship between learners’ views on the use of science process skills and the science process skills learners use to conduct chemistry 5124 practical activities.

Chi-square test was conducted using SPSS and the results obtained are indicated in Table 5.

Table 5: Chi-Square Test results for relationship

	Value	Degree of freedom	Asympt.sig.(2-sided)
Pearson Chi-square	3.274	3	0.351
Likelihood Ratio	3.640	3	0.303
Linear-by-linear Association	2.675	1	0.102
N of valid cases	336		

N=48

Table 5 shows that there was no significant evidence that there was a relationship between views of learners on use of SPS and the SPS learners used to conduct chemistry practical activities (Chi-square =3.272, df=3, $p=0.351>0.05$). Hence, the null hypothesis was accepted. Subsequently, it was established that there was no relationship between views of learners on the use of SPS and actual use of SPS in chemistry practical activities.

4.7 Chapter summary

The chapter presented study findings according to research questions and instruments. Findings on learners' views on use of SPS indicated that they used all the SPS considered, except predicting. However, in actual practice learners only used observing, measuring and classifying at least to the required level but did not use the rest of SPS up to the minimal required level when carrying out chemistry 5124 practical activities. The chapter has also highlighted the SPS in which learners experienced difficulties such as observing, interpreting, inferring, predicting and communicating skills. Finally, it has further been established that there was no relationship between views of learners on the use of SPS and actual use of SPS in chemistry practical activities. The following chapter presents discussion of study findings.

CHAPER 5

DISCUSSION OF FINDINGS

5.1 Overview

This chapter discusses findings according to each research question. That is findings on the views of learners on the use of SPS, SPS learners used to conduct chemistry practical activities, learners' level of use of science process skills to conduct chemistry practical activities and the relationship between learners' views on the use of science process skills and the science process skills learners used to conduct chemistry practical activities.

5.2 Views of learners on use of science process skills in chemistry 5124 practical activities

To start with, findings on understanding of science process skills by learners revealed that they did not know what science process skills are as they failed to provide reasonable definitions and explanations of the said skills. This resonates with study findings of Mbewe, Chabalengula and Mumba (2010), which revealed that pre-service teachers in the Midwest of USA had very poor conceptual understanding of the science process skills. This was worrisome because such prospective teachers did not have sufficient conceptual knowledge of SPS which in turn they were expected to transfer to or help their future learners with, in order to enable them understand science in a meaningful way. Whether this scenario was the same here in Zambia or could have contributed to learners' lack of reasonable understanding of SPS was not established in the current study. However, this situation is possible if teachers who are teaching chemistry 5124 lacked or did not have sufficient conceptual understanding of SPS. This is due to the fact that one could only teach what they know. There are various factors which ought to be investigated in order to establish the real cause of learners' lack of understanding of SPS.

Further, study findings from questionnaires and focus group discussions revealed that learners were of the view that they used all the aforementioned skills, except predicting, in chemistry practical activities. This finding is in line with that of Rambuda (2002) who revealed that teachers applied basic science process skills to the teaching of geography. This implied that learners applied basic science process skills to the learning of geography. In the current study, the bigger percentage of learners who were of the view that they used most of the skills seemed to suggest that, there was quite a good number of learners who used the said process skills in chemistry practical activities. However, due to inconsistencies noted in learners' responses on use of SPS in the survey, discussion and observations, such views left the researcher with no option but to regard them as mere claims. As such, the results from the survey particularly could be deemed to a larger extent as claims by learners. It was further revealed that learners were not given practical opportunities in chemistry. This raises serious concern because practical opportunities, like experiments, enable learners to develop process skills and also practice the developed skills so as to enhance them (Feyzioglu, 2009). Therefore, this would mean that learners' views on use of process skills were just expressions of what would become of them given the chance to do actual practical work.

The trend of not giving practical activities to learners does not only have adverse effects on the acquisition but also on the enhancement of SPS. If learners are not exposed to practical opportunities, it becomes almost impractical for learners to acquire and enhance the already developed SPS, and in the end apply them in their day to day activities. It can further be argued that if learners had the ability to use the SPS then they did not possess them at higher level because such skills do not develop at once but do so gradually through practice. Mulenga and Mbewe (2017) noted that science process skills develop over time and this development is affected by the exposure to practice and frequency of practice. Studies aiming at equipping students with science process skills have concluded that students acquire each skill through certain stages (Saat, 2004). The stages are identified as recognition, making habit and automation of process skills (Feyzioglu, 2009). At the first stage (recognition of a skill), a learner recognizes the skill and related constructs which is mostly achieved at lower-grades. Hence, this stage can be reinforced just as early as a learner starts learning or attending science lessons. Aydogdu and Kesercioglu (2005) indicated that, at the second stage (making habit of a skill) learners get familiarized with the process skill and can provide different examples related to the skill, but cannot use it in different areas as they are experiencing mental confusion. At the third stage (automation of skills), a learner can easily define the terms related to process skills and can apply them to other situations (Aydogdu & Kesercioglu, 2005). The findings of the present study suggest that learners had not yet achieved the last two stages as they were not familiar with SPS and as such failed to explain what they are or give related examples. Therefore, practical opportunities should be given to learners to guarantee their active involvement in the learning processes which eventually sees them go through the said stages with ease.

Chemistry practical opportunities would enable learners put in practice the learnt theory and also construct knowledge on their own. In order to construct knowledge on their own and acquire problem solving skills, learners need to do practical activities that bring science process skills to use. Science process skills form the basis of the ability to conduct scientific inquiry in an effective and efficient manner. The application of the said skills extends beyond classroom practices to solving ones day to day problems. Aydogdu and Kesercioglu (2005) observed that these skills constitute a general definition of the logical and rational thought that an individual uses throughout their lifetime.

5.3 Science process skills learners used to conduct chemistry 5124 practical activities

Use of science process skills is important in learning chemistry, particularly in solving chemistry practical activities. Literature has revealed time and again that acquisition and use of science process skills is crucial in science learning (Akani, 2015; Aydogdu, 2017; Bybee & Deboer, 1993). Science process skills improve conceptual and procedural understanding of learners which in turn improves their performance in chemistry (Feyzioglu, 2009; Garnet & Hackling, 1995).

A study by Aydogdu (2017) revealed that there is a positive correlation between science process skills and students' achievement in science courses. Arising from this perspective, the researcher is of the view that learners' performance in chemistry can be improved by encouraging use of SPS among learners. One of the ways to achieve this stride is by encouraging teachers to employ SPS teaching approach in chemistry lessons. This approach emphasizes the acquisition and use of science process skills among learners (Mweshi, 2007). It is worth noting that acquisition and use of SPS are crucial in the learning of chemistry content. Teachers are supposed to be trained in the aforementioned approach for them to help learners acquire and improve their SPS. It cannot be argued further at this point that SPS are important in chemistry learning experiences.

The findings of the current study from observations revealed that learners successfully used observing, measuring, classifying, while on the other hand they failed to use predicting, interpreting, inferring and communicating in chemistry practical activities at the least required level. These findings are in line with those of Akani (2015) who in his study revealed that students used observing and measuring, and also inferring and communicating skills despite the latter two being at low level of possession among the learners. Use of science process skills is mainly triggered by inquiry teaching or learning approaches (Mbewe et al., 2010; Mwangi, 2016; Mweshi, 2007). This implies teachers ought to embrace inquiry learning experiences to allow learners utilize the SPS. By extension, this calls for teachers to be well informed of such skills. Mbewe et al. (2010) observed that if teachers do not have sufficient conceptual knowledge of science process skills it is difficult for them to help their learners to understand them in a meaningful way. Therefore, teachers need to have the conceptual and procedural knowledge of SPS if they are to help their learners learn chemistry in a meaningful way.

5.4 Learners' level of use of science process skills in chemistry 5124 practical activities

As discussed, earlier findings indicated that learners used few SPS whereas did not use most of the skills at the required level to conduct chemistry practical activities. At first glance percentages for observing, measuring and classifying may seem to depict very good performance by learners but that is not the case when analyzed in detail. A closer look at all the skills, their level of use is particularly worrying considering their grade level. According to the scale used in this study, the findings indicated that learners used observing classifying and measuring at satisfactory levels, while unsatisfactory levels were observed in predicting, interpreting, inferring and communicating. These findings are on one hand consistent and on the other inconsistent with findings of Akani (2015) who investigated the level of possession of observing, measuring, communicating and inferring in college of education final year students in South Eastern States of Nigeria. His study revealed that there was high level possession of observing and measuring skills and low level possession of communicating and inferring. Despite the difference in terminologies on the scale used in these two studies, findings can be related as they investigated the same phenomenon and had almost same object.

For instance, findings of the current study on the level of use of inferring and communicating skills are to a larger extent consistent with findings of Akani (2015). The current study established that communicating and inferring skills were at unsatisfactory level while Akani (2015) also established that these were at low level. Further, the current study revealed that measuring and observing were at satisfactory level while Akani's (2015) study revealed that these skills were at high level of possession. Hence, the findings of the two studies in this regard were not consistent. According to Piagetian theory, the observed differences could be explained by participants' developmental level. Participants in Akani's (2015) study were college students while this study had grade 12 learners. Age differences and particularly education level of participants could have led to the differences noticed. Brotherton and Preece (1996) observed that students at concrete operational stage can successfully implement basic process skills like measuring, and those at formal operational stage can successfully implement integrated process skills like interpreting. This would explain why learners in the current study experienced a lot of when it came to use complex and integrated SPS like interpreting. It also suggests that learners in the present study were possibly still operating at concrete operational stage. Thus, participants in a study by Akani (2015) could be thought to be at a higher intellectual developmental level (formal operational stage) than those in the present study. Therefore, it cannot be argued further for literature has shown that possession or use of science process skills is also dependent on the cognitive level of an individual

(Brotherton & Preece, 1996; Özgelen, 2012). Piaget (1964) contended that there is a positive correlation between children's mental capacity for processing information and their age. Therefore, it can be noted that there is a close link between cognitive development and science process skills.

However, the case, the satisfactory levels of use in SPS such as measuring, observing and classifying skills by most learners in this study could be considered very low. Good to very good performance levels were expected among learners because the aforementioned skills are basic SPS, and so they need to be used by learners at this grade level with efficiency. The unsatisfactory levels in predicting, interpreting, inferring and communicating skills ought to be addressed urgently as well. It is worth to note that unsatisfactory levels observed in the said skills meant that learners did not use those skills at all. Further, the low and unsatisfactory levels in the use of SPS among learners in chemistry 5124 can be traced to none practice of the theory learnt (Mweshi, 2007). Therefore, chemistry teachers should be engaging learners in minds-hands on activities. It is only through such activities that the learners can easily acquire the desired science process skills (Akani, 2015). Furthermore, it becomes vital for teachers who teach chemistry 5124 to pay particular attention to SPS with low and unsatisfactory level such as those mentioned earlier in order to develop and enhance them within learners.

5.4.1 Difficulties experienced by learners in chemistry 5124 practical activities

The findings from all research instruments revealed that learners faced difficulties when using SPS to undertake chemistry practical activities. The difficulties observed in actual practice were to a larger extent similar to those established from group discussions. What the researcher observed while learners conducted practical activities and the views obtained from learners through group discussion corresponded with each other. The difficulties identified by this study further substantiated the fact that learners had inadequate or not yet developed science process skills to the required level for chemistry 5124 practicals. The following were the difficulties learners experienced when undertaking chemistry practical activities as indicated.

i. ***Difficulty in making acceptable predictions in practical activities***. This increases the chances of learners to get incorrect answers or resorting to guess answers which have no scientific support. When this scenario happens, it creates a boundary between learners' understanding of scientific concepts, principles and laws among others and evidence, for science is an evidence-based subject. Therefore, if learners fail to exhibit respect for evidence, one dimension of science content learners need to possess then it can be assumed that they would experience difficulties to succeed in science and science related enterprises. A balance between scientific theories and practice (how they are developed) needs to be achieved in order to overcome or eliminate this kind of difficulty.

ii. ***Failure to correctly write or communicate their observation in a suitable manner***. Communicating observations in an acceptable way is vital in any given activity. An example was given in the case of learner F at school NE shown in Figure 10 earlier. The cited learner failed to give a full description of the sample; despite the learner being able to identify the correct color of the sample, he failed to indicate the physical state of the sample to ensure the correct and full description. In this regard the learner's description of the sample could be considered inadequate. It was established that learners did not have adequate communicating skill.

iii. ***Failure to interpret results from observation***. When a qualitative or quantitative observation is made but without interpretation, then such an observation is meaningless. Failure to interpret observations would imply that either one does not possess prerequisite knowledge for the intended observation or they lack or have inadequacies in the observing skill itself. The former would mean learners did not have sufficient prior knowledge in order to make correct observations. This is so because if correct observations are made at once, interpretation would be seen as a ripple effect and would be meaningful. The latter assumption would mean learners had inadequate or lacked the interpreting skill. This skill being an integrated process skill develops over time. One needs to gain mastery of basic skills in order for them to execute this skill successfully. The study established that most learners were hardly exposed to practical activities. It is in such opportunities where learners would develop and practice the developed interpreting skill. Failure to practice this skill guarantees failure in its execution in various activities. Therefore, it is not surprising having observed that learners had difficulties in interpreting because they were not given opportunities to develop and enhance this skill in the first place.

iv. ***Failure to draw conclusions from observations and failing to relate observations to scientific theories***. As it was observed in qualitative tasks, a good number of learners struggled to relate observations on color changes particularly to notes for qualitative analysis. This led them to give generalized answers and not referring to the specific samples that were given in the tasks. At the very heart of every practical activity lies a conclusion. One needs to summarize the entire process by means of giving a conclusion. Conclusion could be based on trends observed, principles and so on. Arriving at a correct conclusion in this regard is so much dependent on inferring skill. Therefore, the fact that learners had difficulties in making correct conclusion(s) would mean that learners either did not possess or had inadequacies in inferring skill which ultimately affected their answers to given questions.

The foregoing difficulties observed could be traced to various factors. For instance, inadequacies leading to difficulties in SPS could be perpetuated by learners themselves or by teachers. Teachers have a bigger role to play in this part as they are charged with the responsibility of planning for most of learning experiences. Ultimately, teachers play a pivotal role in ensuring that learners develop or enhance SPS in chemistry. However, if teachers fail to take into account appropriate learning experiences, strategies and methods among others, then they would to a larger extent be held accountable for learners' failure in this case. Feyzioglu (2009) advanced that, teachers should themselves possess and use practical skills efficiently so as to equip their students with SPS in the classroom environment. A teacher who is not properly equipped with SPS may in turn experience difficulties to deliver these skills to their students (Luft, 2001; Mbewe et al., 2010; Osborne et al., 2003). If teachers have difficulties to apply SPS, it is common sense that their learners too would encounter similar difficulties in using them. This would explain why a lot of teachers resort to teach chemistry theoretically only and neglect the practical part. Sahin-Pekmez (as cited in Feyzioglu et al., 2011) found that teachers, who did not possess SPS, did not use laboratory activities efficiently and avoided performing experimental activities in class, thus taught chemistry courses mainly theoretically. This is worrying and calls for collaborative efforts from relevant stakeholders to ensure that chemistry teachers are well informed of SPS as well as trained in the effective and efficient ways of teaching them. This could be done at college or university level to student teachers by engaging them in practical activities regularly, and through CPDs for in-service teachers.

The findings on difficulties learners experienced in chemistry 5124 practical activities to a larger extent resonates with observations indicated in annual examination reports on the performance of the Senior Secondary School Certificate Examination for natural sciences in two consecutive years (ECZ, 2016; 2017). The two reports indicated that learners had challenges in practical examinations most of which were to do with use of aforementioned SPS. The present study has established that the difficulties experienced in chemistry 5124 practical activities can be attributed to learners' inability and insufficient to use SPS. This raises a serious concern as literature has shown that use of science process skills is crucial both in science learning and the development of a society (Akani, 2015). Therefore, if our societies and nation at large are to develop as desired in our vision 2030, suitable measures and interventions should be deliberately put in place to address these issues.

5.5 The relationship between views of learners on use of science process skills and the science process skills learners used in chemistry 5124 practical activities

Findings on this item revealed that there was no relationship between learners' views on use of SPS and the SPS which learners used to conduct chemistry 5124 practical activities. There were in most cases inconsistencies in learners' responses in questionnaires and focus group discussions with results obtained by observations.

Thus, findings from the survey could be reckoned to a larger extent as mere claims by learners and thus findings from observations were upheld. The claims by learners to use SPS in practical activities utmost display the desire they have to use SPS in learning experiences. Such desire could be taken as motivating factor to equip learners with SPS and encourage them to apply such skills to solve various classroom tasks and everyday activities. Further, the findings of the current study are consistent with the findings of Mulenga and Mbewe (2017) who observed that, responses of learners from questionnaires were just mere claims of the learners' ability to use science process skills in physics practical activities as they were not consistent with the observations from the actual practice. These studies are important as they have shown and justified the beauty of triangulating data collection methods if findings of studies of this nature are to be plausible. Therefore, multiple methods of data collection are essential in achieving full understanding of some phenomena under investigation.

5.6 Chapter summary

The chapter discussed study findings according to research questions. Findings of the present study were related to existing literature, and it was established that some were consistent with literature while others were not. Particularly, the finding for the first, second and last research questions were in most cases consistent with literature whereas those for the third one were on one hand consistent with some literature and inconsistent with others. The reasons for such variations and observations were also discussed in this chapter. The following chapter presents the conclusion and recommendations of the study.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6. 1 Overview

This chapter presents the conclusion and recommendations of the study based on the current findings.

6.2 Conclusion

The study concluded that learners were of the view that they used all the SPS under consideration in the study except predicting to conduct chemistry 5124 practical activities. In actual practice, learners did not use most of the SPS they claimed to use to the least required (satisfactory) level. Particularly, they used observing, measuring and classifying at satisfactory level, but did not use interpreting, inferring, predicting and communicating to the least required level when carrying out chemistry 5124 practical activities. The study further concluded that learners experienced difficulties in interpreting, inferring, predicting and communicating skills when undertaking chemistry 5124 practical activities. The difficulties which learners experienced were inevitable owing to the fact that they were not given practical opportunities in chemistry 5124 lessons. Finally, it was concluded that there was no relationship between views of learners on the use of SPS and the SPS they used to conduct chemistry 5124 practical activities.

6.3 Recommendations

In view of the research findings of this study, the following recommendations have been made:

i. Acquisition of science process skills and enhancement of developed process skills among learners should be reinforced in chemistry 5124 lessons. It proves cardinal that teachers emphasize more on acquisition of science process skills and enhancement of developed process skills among their learners during learning experiences. In this regard practical (hand-minds on) activities should be conducted regularly in schools. This would expose learners to practice more on use of SPS in practicals in order to develop and enhance developed science process skills, and also attain broader understanding of chemistry as a whole.

ii. Learners should be drilled on how to efficiently and effectively use SPS in chemistry 5124 practical activities. Chemistry 5124 teachers should pay particular attention to process skills especially those established in this study to be at low and unsatisfactory levels of use such as inferring, interpreting and communicating among other skills in order to develop and enhance them in learners. This can be achieved by using science process skills teaching approach among others in chemistry lessons. This in essence calls for teachers to be abreast with such teaching approaches. The implication here is to deliberately train teachers in the said approaches either through CPDs or pre-service teacher programs.

iii. When designing practical activities, the cognitive development level of learners should be taken into consideration because the level of possession or use of process skills is so much dependent on the cognitive developmental level of an individual (Brotherton & Preece, 1996; Özgelen, 2012). Teachers need to bear in mind that SPS develop gradually and that some process skills appeal to higher order thinking than others and ought to be treated as such. Therefore, teachers should consider mental age and different individual's learning abilities of learners when planning practical activities.

6.3.1 Areas for further research

i. A similar study should be extended to other grades not considered in this study. Most especially at junior secondary where practicals have also been introduced in integrated science final examinations.

ii. A longitudinal study on chemistry 5124 teachers should be done in order to get in-depth understanding of the practical activities they plan and deliver to learners. This would help to understand the issue from a different dimension thereby enriching our understanding about science process skills in this subject.

6.4 Chapter summary

The chapter presented conclusions and recommendations based on findings with respect to research objectives. The study concluded that learners' views on use of SPS were not consistent with their actual use in chemistry 5124 practical activities. Learners did not use most of the SPS to the minimal required level. Thus, it was further concluded that there was no relationship between views of learners on the use of SPS and the SPS they used to conduct chemistry 5124 practical activities. Finally, the chapter outlined study recommendations and areas for further research.

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APPENDICES

Appendix A: Questionnaire for Chemistry 5124 Learners

Dear Respondent,

I am a student at the University of Zambia. I am carrying out a research which is attempting to ascertain the Science Process Skills used by learners in Chemistry Practical activities. Feel free and be as honest as possible in responding to the questions. True and honest responses will provide vital information on science process skills for chemistry 5124 practical activities which could be useful to chemistry teachers, curriculum planners and learners among other stakeholders.

Kindly answer the questions according to the instructions given on each particular question. Your response will be treated with strict confidence, and will only be used for the purpose of this study. After completing the questionnaire hand it to me or your chemistry teacher who will then return it to me.

For official use only	
Respondent's code: …………………	School Code: …………………….

Questions:

Part one: Personal data (tick on appropriate answer).

1. What is your gender?

	Tick below
Male	
Female	

2. What is your age in years? ………………………..

Part two: Learning chemistry using practical activities.

3. Our teacher gives us practical activities to identify chemistry important problems.

	Tick below
Yes	
No	

4. How many times do you have practical activities in chemistry?

A. None [ ] B. Once a week [ ] C. Twice a week [ ] D. Thrice a week [ ] E. Other [ ], Specify ……………………………………………………………….

5. Measuring of quantities, classifying objects, observing experiments, communicating experimental results, predicting experimental outcomes, interpreting and making conclusion based on observations are examples of science process skills among others. What do you understand by science process skills? …………………….……………..
6. Do you use any of the mentioned science process skills in Question11, in chemistry practical activities? A. Yes [ ] B. No [ ] C. not sure [ ] (tick on your appropriate response)

   If your response is **No** to this question (Q6) skip the following questions and go to 9.
7. Given the following examples of the descriptions of science process skills, identify what you can do in chemistry practical activities. Below are 7 statements that you may agree or disagree with, using the 1-5 scale where 1-strongly agree, 2-agree, 3-nei*ther* agree no*r* disagree, 4-disagree & 5-strongly disagree, answer each of the following (tick the appropriate value) as they apply to yourself.

s/no.	I can…	Tick below				
		1	2	3	4	5
I	Observe scientific phenomena such as changes in temperature, color, state and so on.					
II	Use standard and non-standard measures to describe dimensions or organize activities in which I compare units of measure and suitable measuring instruments.					
III	Communicate learnt information and use words, graphs, tables or symbols to describe a chemistry activity.					
IV	Classify or arrange science phenomena such as elements, compounds and reactions based on their observable pattern and characteristics.					
V	State the expected outcome of a future event based on a pattern of evidence.					
VI	Organize, conclude from data and make sense of data in a given chemistry experiment.					
VII	Explain an observations and data collected from the given chemistry practical activity.					

Part three: Difficulties experienced in using process skills.

8. How do you find using each of the following process skills? Using the scale of 1-5 indicate your response by a tick on the value as they apply to yourself.

Key : 1-Very hard to use, 2-fairly Hard to use, 3- fairly Easy to use, 4-Very easy to use & 5-Not sure.

Difficulty in using science process skills					
Process skills	Level of difficulty (scale)				
	1	2	3	4	5
I. Observing events in chemistry experiments					
II. Communicating observations					
III. Making inference or conclusion in experiments.					
IV. Measuring physical quantities e.g. mass, volume, temperature.					
V. Predicting events in experiments					
VI. Interpreting gathered data/information in experiments					
VII. Classifying chemistry phenomena					

9. State difficulties (if any) which you experience when science process skills are applied to the learning of chemistry. ……………………………………...
   ……………………………………………………………………………………
10. State how you address the difficulties mentioned in Question 9 above.
   ……………………………………………………………………………………

End of questions

Thank you for your co-operation

If you have any queries regarding this study, please contact the researcher,

Mr. Ng'andu Sunday, Cell:0968865019, e-mail address: ngandusunday@gmail.com

Appendix B: Observation Schedule for Chemistry 5124 Practical activities.

The observation schedule was used to collect data regarding science process skills used by learners in practical activities.

Part one: Demographic data

School code: ………. Number of learners: Boys ………. & Girls ……………....

Part two: Science process skills used by learners during chemistry practical activities. The following scale was used as a guide to indicate the skill performed by the learner.

Scale: 0-no attempt, 1-Unsatisfactory, 2-Satisfactory, 3-Good, 4-Very good.

	Learner's identity / Science Process Skills	Code/ gender												
		Code	A	B	C	D	E	F	G	H	I	J	K	L
		Gender M or F												
1	**Observing**													
	Ability to use senses to identify characteristics or properties of substances.													
	Ability to identify qualitative changes (color, or temperature) in conditions.													

2	**Measuring**													
	Ability to identify suitable device/apparatus for measuring quantities and use it correctly.													
	Ability to repeat measurement to and using average value of measures obtain more appropriate values.													
	Ability to specify units of measurements using the correct S.I. Units.													
3	**Classifying**													
	Ability to identify similarities and differences between or among substances based on their characteristics.													
	Ability to categorize events or objects based on their characteristics or properties.													
	Ability to arrange substances in a given order (ascending or descending order) based on their properties or states and so on.													
4	**Predicting**													

	Ability to give a scientific-guess on likely results of events before the experiment comes to an end.												
	Ability to state the outcome of a future occurrence based on observations.												
5	**Interpreting**												
	Ability to organize data and attaching meaning to it.												
	Ability to explain an observations and data collected from the given chemistry practical activity.												
6	**Inferring**												
	Ability to draw reasonable conclusions based on observation.												
	Ability to relate initial assumptions with experimental results.												
	Ability to specify relevant conclusion at each stage of an experiment.												
7	**Communicating**												

	Ability to use symbols, chemical formulae and numbers appropriately.													
	Ability to express observations in correctly (acceptable language).													
	Ability to express observation in quantitative description.													

Part three: Difficulties experienced by learners as observed in chemistry practical activities.

S/No.	Learner's ID	Difficulties experienced by learners on SPS components
1	A	
2	B	
3	C	
4	D	
5	E	
6	F	
7	G	
8	H	
9	I	
10	J	
11	K	
12	L	

THE END

Appendix C: Science process skills assessment instructions (SPSAI).

School code: …………….....   Date: …..………………   Duration**:** 1hr: 30min**.**

Learner's code: ……………   Learner's gender**:** ……..…. (Indicate male or female).

Instructions: This activity consists of three (3) parts; attempt all the questions in this activity.

Part one: You are provided with substances X, Y & Z, and 0.1mol/dm^3 hydrochloric acid.

Put a small piece of the given substances in test tube and add equal volume (5M) of acid to each test tube in order to determine their reactivity. Record your results in the table below.

Test no.	Test	Observation
1.	To a small portion of X and add little volume of acid.	
2.	To a small portion of Y and add little volume of acid.	
3.	To a small portion of Z and add little volume of acid.	

Summary:

i. Which among the substances X, Y or Z is;

a. The most reactive? ……………………………………………………………..

b. The least reactive? ………………………………….……………………..

ii. Give a reason for you answer in (i) above: …………………………………..

……………………………………………………………………………………..

iii. Rank substances X, Y & Z in ascending order of their reactivity.

…………………………………………………………………………………

iv. What would happen if X was put in a solution containing Z?

……………………………………………………………………………………

……………………………………………………………………………………

v. What would happen if Z was placed in a solution containing X?

……………………………………..………………………………………

…………………………………………………………………………..

Part two: **P** is a solution of hydrochloric acid, HCl, prepared by standardization. You are required to determine the volume of hydrochloric acid which would neutralize 25cm ^{3} of Q. **Q** is sodium hydroxide, NaOH, with concentration 0.001mol/dm^3.

Put **P** in the burette. Measure or Pipette 25.0cm^3 of **Q** and transfer it completely into a clean dry conical flask. Add 3 drops of the indicator provided and then titrate **P** & **Q**. Repeat the titration procedure as many times as you consider necessary to achieve consistent titration results.

Record your results in the table below.

Results

Burette reading/cm^3

Titration no.	Rough	1	2	3	4
Initial reading					
Final reading					
Volume of **P** used					
Tick best result					

Summary: ______________________cm^3 of Q (sodium hydroxide: NaOH) requires an average of _______________________cm^3 of P (Hydrochloric acid: HCl).

Part three: You are provided with samples **S**. You are to carry out the test indicated in the table. Record your observations in the table below. **S** contains one Cation and one Anion specified in the 5124/3 syllabus.

Test no.	**Test**	**Observation**
1.	a) Describe the appearance of **S.**	
2.	a) To a small portion of **S** add a few drops of sodium hydroxide until a change is seen.	
	b) To the mixture in (a) add excess of sodium hydroxide.	
3.	a) To a small portion of **S** add a few drops of aqueous ammonia.	
	b) To the mixture in (a) add excess ammonia.	
4.	a) To a small portion of **S** add a small portion of barium nitrate solution.	
	b) To the mixture in (a) add a small amount of nitric acid.	

Conclusion

i. The formula of cations and anions in S is

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

ii. The formula of the salt in solution S is

……………………………………………………………………………

iii. The identity test number used to identify anion in S is

……………………………………………………………………………

The end of activities

Qualitative Analysis notes (for part three).

i. Test for anions (negatively charged particles)

Anion	Test	Test result
Carbonate (CO_3^{2-})	Add dilute acid	Effervescence, carbon dioxide produced
Chloride (Cl^-) [in solution]	Acidify with dilute nitric acid, then add aqueous silver nitrate	White ppt
Iodide (I^-) [in solution	Acidify with dilute nitric acid, then add aqueous lead(II) nitrate	Yellow ppt
Nitrate (NO_3^-) [in solution]	Add aqueous sodium hydroxide, then aluminium foil; warm carefully	Effervescence, Ammonia produced
Sulphate (SO_4^{2-}) [in solution]	Acidify with dilute nitric acid, then add aqueous barium nitrate	White ppt

ii. Test for aqueous cations (i. e positive ions in solution)

Cation	Effect of aqueous sodium hydroxide	Effect of aqueous ammonia
Aluminium (Al^{3+})	White ppt., soluble in excess giving a colourless solution	White ppt., insoluble in excess
Ammonium (NH_4^+)	Ammonia produced on warming	-
Calcium (Ca^{2+})	White ppt., insoluble in excess	No ppt. or very slight white ppt
Copper(II) (Cu^{2+})	Light blue ppt., insoluble in excess	Light blue ppt., soluble in excess giving a dark blue solution
Iron(II) (Fe^{2+})	Green ppt., insoluble in excess	Green ppt., insoluble in excess
Iron(III) (Fe^{3+})	Red-brown ppt., insoluble in excess	Red-brown ppt., insoluble in excess
Zinc (Zn^{2+})	White ppt., soluble in excess	White ppt., soluble in excess giving a colourless solution.

iii. Test for gases

Gas	Test and test result
Oxygen (O_2)	Relights a glowing splint
Hydrogen (H_2)	Pops with a lighted splint
Carbon dioxide (CO_2)	Turns lime water milky
Ammonia (NH_3)	Turns damp red litmus paper blue
Sulphur dioxide (SO_2)	Turns aqueous potassium dichromate(VI) green
Chlorine (Cl_2)	Bleaches damp litmus paper

Appendix D: Focus Group Discussion Guide for Chemistry 5124 Learners

This discussion guide was used to collect data on learners' views on science process skills in chemistry 5124.

Demographic data

Group code: …….……………………. School code: ………………………………

Questions:

1. Describe science process skills…..…………………………………………
   ………………………………………………………………………………
2. Do you use (if any) use science process skills in chemistry practical activities? If yes, which ones? ....
   ………………………………………………………………………………..
3. Do you think science process skills are important in learning chemistry? Give a reason for your answer …………………………......................................
   ………………………………………..…………………………………
4. Given the following science process skills, rank them in increasing order of difficulty: observing, measuring, predicting, interpreting, inferring and communicating……………………………………………………………
   ……………………………………………………………………………….
5. With regard to use of science process skills, do you face any difficulties when carrying out chemistry practical activities (if any)? What are these difficulties and how do you handle them?
   ………………………………………………………………………………
   ………………………………………………………………………………
   ………………………………………………………………………………

End of discussion

Thank you for your co-operation

Appendix E: Ethical Clearance

THE UNIVERSITY OF ZAMBIA

DIRECTORATE OF RESEARCH AND GRADUATE STUDIES

Great East Road | P.O. Box 32379 | Lusaka 10101 | **Tel:** +260-211-290 258/291 777
Fax: +260-1-290 258/253 952 | **Email:** director@drgs.unza.zm | **Website:** www.unza.zm

Approval of Study

17th May, 2019

REF NO. HSSREC: 2019-JAN-027

Ng'andu Sunday
University of Zambia
School of Education
Department of Mathematics and Science Education
Box 32379
LUSAKA

Dear Mr. Ng'andu,

RE: "LEARNERS' SCIENCE PROCESS SKILLS FOR CHEMISTRY 5124 PRACTICAL ACTIVITIES: A CASE OF SELECTED SECONDARY SCHOOLS OF KITWE DISTRICT"

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: 17th May, 2019	Expiry Date: 16th May, 2020
Protocol Version and Date	Version-Nil	16th May, 2019
Information Sheet, Consent Forms and Dates	• English.	To be provided
Consent form ID and Date	Version	To be provided
Recruitment Materials	Nil	Nil

1

Excellence in Teaching, Research and Community Service

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 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.

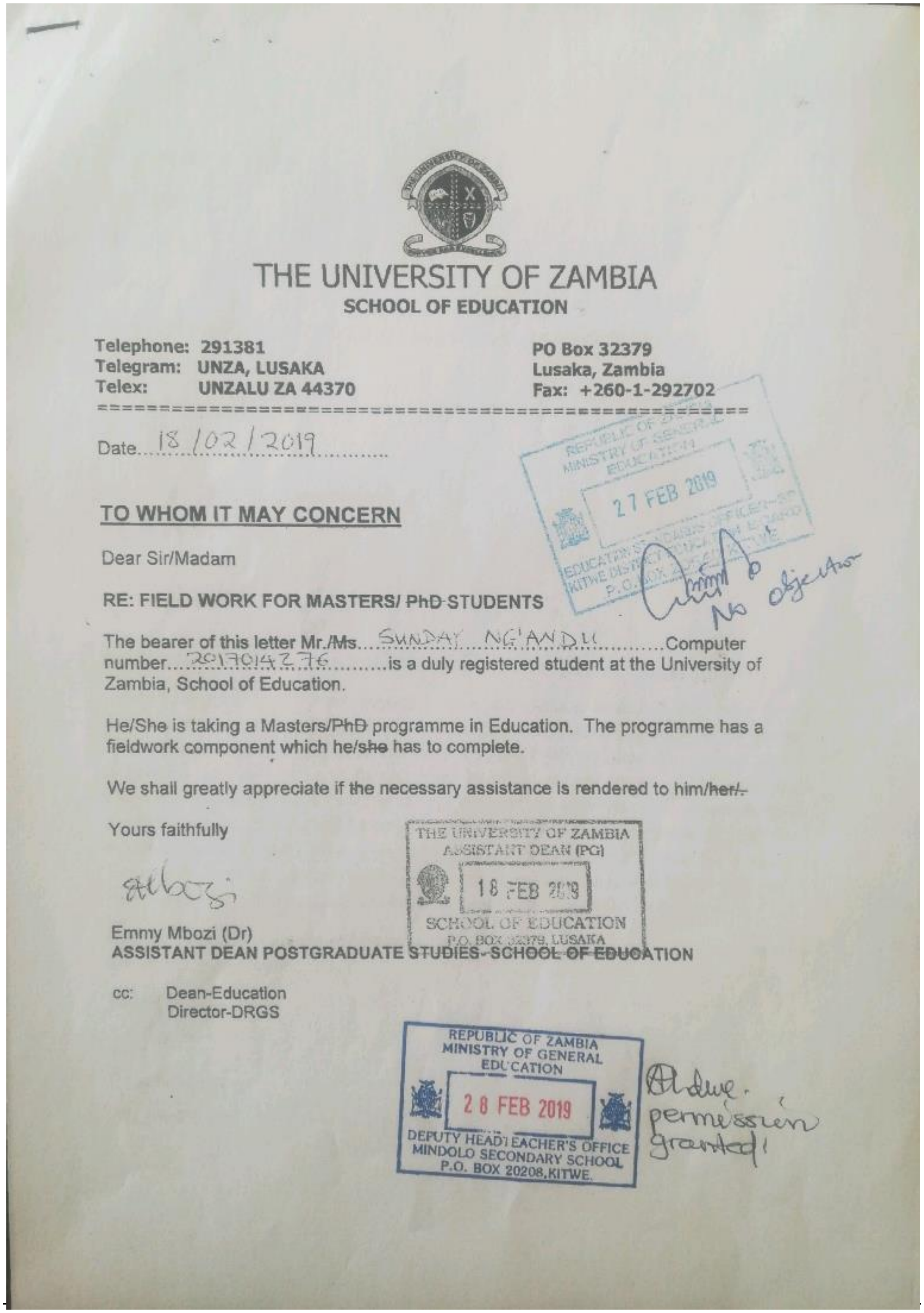
On behalf of The University of Zambia Humanities and Social Sciences Research Ethics Committee (IRB), we would like to wish you all the success as you carry out your study.

Yours faithfully,

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

cc: Director, Directorate of Research and Graduate Studies
Assistant Director (Research), Directorate of Research and Graduate Studies
Assistant Registrar (Research), Directorate of Research and Graduate Studies
Senior Administrative Officer (Research), Directorate of Research and Graduate Studies

Appendix F: Schools' permission letters



THE UNIVERSITY OF ZAMBIA
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Date 18/02/2019

REPUBLIC OF ZAMBIA
MINISTRY OF GENERAL EDUCATION
27 FEB 2019
EDUCATION STANDARDS OFFICER
KITWE DISTRICT
P.O. BOX

TO WHOM IT MAY CONCERN

Dear Sir/Madam

RE: FIELD WORK FOR MASTERS/ ~~PhD~~ STUDENTS

No objection

The bearer of this letter Mr./~~Ms~~ SUNDAY NG'ANDU Computer number 2017014376 is a duly registered student at the University of Zambia, School of Education.

He/~~She~~ is taking a Masters/~~PhD~~ programme in Education. The programme has a fieldwork component which he/~~she~~ has to complete.

We shall greatly appreciate if the necessary assistance is rendered to him/~~her/~~.

Yours faithfully

THE UNIVERSITY OF ZAMBIA
ASSISTANT DEAN (PG)
18 FEB 2019
SCHOOL OF EDUCATION
P.O. BOX 32379, LUSAKA

Emmy Mbozi (Dr)
ASSISTANT DEAN POSTGRADUATE STUDIES- SCHOOL OF EDUCATION

cc: Dean-Education
Director-DRGS

REPUBLIC OF ZAMBIA
MINISTRY OF GENERAL EDUCATION
28 FEB 2019
DEPUTY HEADTEACHER'S OFFICE
MINDOLO SECONDARY SCHOOL
P.O. BOX 20208, KITWE

Adue. permission granted!

REPUBLIC OF ZAMBIA
MINISTRY OF GENERAL EDUCATION
25 MAR 2019
DEPUTY HEADTEACHER
CHIMWEMWE SECONDARY SCH

THE UNIVERSITY OF ZAMBIA

SCHOOL OF EDUCATION

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Date 18/02/2019

REPUBLIC OF ZAMBIA
MINISTRY OF GENERAL EDUCATION
27 FEB 2019

No objection

TO WHOM IT MAY CONCERN

Dear Sir/Madam

RE: FIELD WORK FOR MASTERS/ ~~PhD~~ STUDENTS

The bearer of this letter Mr./~~Ms~~ SUNDAY NG'ANDU Computer number 2017014276 is a duly registered student at the University of Zambia, School of Education.

He/She is taking a Masters/~~PhD~~ programme in Education. The programme has a fieldwork component which he/~~she~~ has to complete.

We shall greatly appreciate if the necessary assistance is rendered to him/~~her~~.

Yours faithfully

THE UNIVERSITY OF ZAMBIA
ASSISTANT DEAN (PG)
18 FEB 2019
SCHOOL OF EDUCATION
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Emmy Mbozi (Dr)
ASSISTANT DEAN POSTGRADUATE STUDIES- SCHOOL OF EDUCATION

cc: Dean-Education
Director-DRGS

REPUBLIC OF ZAMBIA
MINISTRY OF GENERAL EDUCATION
29 MAR 2019
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===

Date 18/02/2019

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27 FEB 2019
EDUCATION STANDARDS OFFICER
KITWE DISTRICT

No objection

TO WHOM IT MAY CONCERN

Dear Sir/Madam

RE: FIELD WORK FOR MASTERS/ PhD STUDENTS

The bearer of this letter Mr./Ms. SUNDAY NG'ANDU Computer number 2017014276 is a duly registered student at the University of Zambia, School of Education.

He/~~She~~ is taking a Masters/~~PhD~~ programme in Education. The programme has a fieldwork component which he/~~she~~ has to complete.

We shall greatly appreciate if the necessary assistance is rendered to him/~~her/~~.

Yours faithfully

THE UNIVERSITY OF ZAMBIA
ASSISTANT DEAN (PG)
18 FEB 2019
SCHOOL OF EDUCATION
P.O. BOX 32379, LUSAKA

Emmy Mbozi (Dr)
ASSISTANT DEAN POSTGRADUATE STUDIES- SCHOOL OF EDUCATION

cc: Dean-Education
Director-DRGS

D/Head
FYA

REPUBLIC OF ZAMBIA
MINISTRY OF GENERAL EDUCATION
25 MAR 2019
HEADTEACHER'S OFFICE

THE UNIVERSITY OF ZAMBIA
SCHOOL OF EDUCATION

Telephone: 291381
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PO Box 32379
Lusaka, Zambia
Fax: +260-1-292702

Date 18/02/2019

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ASSISTANT DEAN POSTGRADUATE STUDIES- SCHOOL OF EDUCATION

cc: Dean-Education
Director-DRGS

4 MAR 2019
HOD
NATURAL SCIENCES

Appendix G: Participants' Consent Form

1. I have fully discussed the research project to be undertaken by Ng'andu Sunday titled 'Learners' science process skills for chemistry 5124 practical activities: A case of selected secondary schools of Kitwe district', whose purpose is to investigate the use of science process skills by learners in chemistry practical activities.
2. I fully understand the purpose and give approval to participate by:
    - i. Taking part in a survey.
    - ii. Being observed in chemistry practical activities.
    - iii. Taking part in focus group discussion.
3. My participation, however, is on conditions that:

v. Authority has been given for research to be done in this school.

vi. I can ask the researcher or his supervisor any questions about the study.

vii. The only people who will see the information will be the researcher and his supervisor(s).

viii. The findings of the study will be used for academic purposes only.

ix. There will be no written reports in which the school and I could be identified.

x. I can withdraw from being involved in the study at any stage without having to give any reason for doing so.

Thank you.

Participant's signature: ………………………………………..

Date: ………………………………………………………….