AN INVESTIGATION INTO THE TEACHING OF BIOLOGY AND PHYSICAL SCIENCE PRACTICAL WORKS IN SENIOR SECONDARY SCHOOLS IN THE ZAMBEZI REGION, NAMIBIA

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APPROVAL PAGE

This research has been examined and is approved as meeting the required standards for partial fulfilment of the requirements of the degree of Master of Education (Science Education).

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External examiner Date

DECLARATION

I, Liswaniso Joseph Liswaniso, hereby declare that this thesis: *Investigating the teaching of practical works in Biology and Physical Science in the senior secondary schools in Zambezi Region, Namibia*, is a true reflection of my own research, and that this work, or part thereof has not been submitted for a degree in any other institution of higher learning.

Mr. Liswaniso Joseph Liswaniso ……

Signature **Date**

DEDICATION

This thesis is dedicated to my mother *HAGUBA REGINA MBULA* and the loving memory of my late father, *SINJABATA GREENWELL LISWANISO* who without attending any formal education strived to see me educated. Thank you for inspiring me to undertake this transformational journey in my lifetime and giving my academic life so much meaning.

Furthermore, I would like to dedicate this thesis to my son LWENDO LISWANISO and daughter SOPHIA LISWANISO, for allowing me to sacrifice the valuable time that I should have spent with you. I will always love you.

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ABSTRACT

This study aimed at investigating the teaching of Biology and Physical Science practical works in Senior Secondary schools in the Zambezi Region, Namibia. The study was guided by four questions:

1. Did the teaching of Biology and Physical Science practical works in Senior Secondary schools in the Zambezi region follow the learning objectives outlined in the subjects' curricula?;
2. What practical skills do the Biology and Physical Science teachers aim to achieve from the practical works being taught in the Senior Secondary schools?;
3. What assessment criteria are used by the Biology and Physical Science teachers to assess the practical skills acquired by the learners?
4. What are the opinions of the Biology and Physical Science teachers on the things that should be done to improve the teaching of Biology and Physical Science practical works in Senior Secondary schools in the Zambezi region?

Mixed method research design involving both qualitative and quantitative research approaches were employed to collect data. A sample consisting of seven Biology teachers and seven Physical Science teachers were selected using the purposive sampling method. Data were collected through questionnaires, observation schedules, interview schedules and document analysis. Descriptive statistics were used to analyze quantitative data while thematic analysis method was used to analyse the qualitative data.

The findings from the questionnaires and interviews analyses indicated that the majority of Biology and Physical Science teachers taught practical works. Classroom observations and document analyses however, revealed that the teaching of Biology and Physical Science practical works in senior secondary schools in the Zambezi Region was neglected and did not follow the learning objectives outlined in the subjects' curricula. The findings also revealed that the Biology and Physical Science teachers assessed practical skills but gave a higher assessment weighting to the following sequence of instructions; handling apparatus; applying scientific knowledge and understanding to make interpretations and to draw appropriate conclusions from practical observations and data.

The findings also showed that the materials necessary for teaching practical works were not adequate in both Biology and Physical Science classrooms and laboratories. This situation needs to be seriously addressed if the teaching of Biology and Physical Science practical work is to follow the learning objectives outlined in the subjects' curricula. The Ministry of Education should provide resources, equipments and training workshops for Biology and Physical Science teachers on how to teach practical work.

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ACRONYMS

NSSCO	Namibia Senior Secondary Certificate Ordinary Level
DNEA	Directorate of National Examination and Assessment
DAG	Document analysis guide
BS	Biology syllabus
PSS	Physical Science syllabus
BSW	Biology scheme of work
PSSW	Physical Science scheme of work
BLP	Biology lesson plan
PSLP	Physical Science lesson plan
LBWB	Learners' Biology work-book
LPSWB	Learners' Physical Science workbook
BETD	Basic Education Teacher Diploma
B.ED	Bachelor of Education
HED	Higher Education Diploma
M.ED	Master of Education
SSS	Senior Secondary School

CHAPTER 1

INTRODUCTION

1.1 Orientation of the study

The general objectives of teaching practical work in science include motivating and stimulating learners' interest in science, enhancing the learning of scientific concepts, developing the learners' scientific attitude such as open-mindedness and objectivity, teaching practical skills to enable learners handle and manipulate equipment, giving insight into the scientific methods as well as developing expertise in using them (Hodson, 1990). However, in Namibia, the senior secondary Biology and Physical Science curricula are divided into three domains, A (Knowledge with understanding), B (Handling information, application and solving problems) and C (Practical skills and abilities). The present study focuses on Domain C, which deals with practical work (Kandjeo-Marenga, 2011). Domain C indicates the intended learning outcomes for practical work, i.e. to enable learners to develop experimental and investigative skills as stipulated in the Namibia Senior Secondary Certificate Ordinary Level curriculum (Ministry of Education, 2009). All these learning outcomes can be achieved by the teacher through giving innovative and appropriate teaching of the learners. The Biology and Physical Science teachers are therefore required to teach practical works with appropriate teaching pedagogies that has the potential to develop learners' abilities to acquire experimental and investigative skills.

In recent times, there has been an on-going debate concerning the teaching of practical works in Biology and Physical Science by secondary school science teachers. According to Kasanda, Kapenda, Kandjeo-Marenga & !Gaoseb, (2001),

Science teaching in Namibia is basically theoretical and the teaching of practical works is neglected in most secondary schools. The teaching of practical works is theory driven instructions and is not a way for learners to acquire practical skills. In most secondary schools, practical work is not conducted because of the inadequacy of the teachers' professional teaching skills that they bring to the classrooms (Kasanda et.al, 2001).

In Namibia, teachers are expected to teach practical work to provide learning opportunities that will enable learners to acquire the intended learning outcomes (Ministry of Education, 2009). It is through practical work that learners may be involved in different activities that may enhance their abilities to handle information, solve problems, develop experimental skills and learn how to plan investigations. According to Kasanda et.al, (2001), learners seem to learn very little practical work and find learning of science to be difficult, boring and not interesting to them. Mawazo (2010) reported that most learners tend to perform poorly in Biology and Physical Science, and it is thought that among the reasons that has contributed to this poor performance might be the pedagogy used in the teaching of practical work. The teaching of practical work has been questioned, criticised and associated with the poor performances of learners in Biology and Physical Science Paper 3 (Ministry of Education, 2009).

Mawazo (2010) stated that when the teaching is linked with and follows the learning outcomes, then learners are expected to acquire the intended skills. Nakanyala (2015) in his study on the factors affecting the effective teaching of Physical Science; noted that effective teaching depends, to a large extent, on the amount of planning that the teacher puts in before the class. Similarly, Shadrek and Isaac (2012) believed that

science teachers can enhance teaching by using good teaching methods, including practical work. In addition, teachers should have the ability to employ practical investigations in their classrooms to bring about good teaching. Nakanyala (2015) further stated that learners are motivated not only by teachers who knows how to teach science but also those who help them learn through practical work and make learning fun.

Amoonga and Kasanda (2011) found that teachers in Namibian schools prefer to use the lecture method and concentrated on teaching rules more than employing innovative teaching strategies in teaching science. In developing countries, practical work is rarely conducted and the traditional transmission method still prevails (Kandjeo-Marenga, 2008). The author argued that practical work is conducted mainly in the form of demonstrations. She asserted that such practices could deny learners the opportunity to develop practical skills as emphasized in the Biology and Physical Science curriculum.

Other studies reported that poor laboratory organisation, lack of management techniques and poorly co-ordinated practical activities reduced the quality of science teaching and learning (Akale & Nwankwonta, 1996). Hodson (1993) also found the shortage of equipment and materials for fruitful practical works; especially in view of overcrowded classes in most schools as an impediment to the teaching of practical works. Some other researchers attributed the low percentage of learners who pass practical examinations in science, to dissatisfaction with the syllabus, teachers'qualifications, workload, experience, lack of teaching skills, and the ineffective style of delivery of subject matter (Millar, 2004).

Teaching methods of practical work are the most important techniques employed by teachers to realize the objectives of a practical lesson (Buabeng, Ossei-Anto, & Ampiah, 2014). Thus, teachers of senior secondary Biology and Physical Science ought to use various teaching methods for achieving lesson objectives. For Biology and Physical Science learners to acquire practical skills, it would be essential that teachers engage in effective teaching practices (Buabeng, et.al, 2014).

Classroom based investigation has been able to determine teaching practices that are related to positive learning outcomes. In a review of research studies that showed an impact on learners' achievement and learning, (Buabeng, et.al, 2014) summarized teaching methods and outlined five teaching behaviours to which science teachers should pay attention. These behaviours are: lesson clarity; instructional variety; teacher task orientation; and engagement of learners in the learning process (Buabeng, et.al, 2014) .

A study by Buabeng and Ntow (2010) revealed a wide range of reasons which accounted for learners' poor performance in Physical Science in Ghana. Prominent among these factors were teacher factor. Most of the learners reported that there is poor performance in Physical Science at the Senior High School level because practical work was poorly taught to them. Thus, Science teachers should adapt their teaching of practical work in a way that would enable them to achieve the intended learning outcomes. Nonetheless, the question is, "Did the teaching of Biology and Physical Science practical works in Senior Secondary Schools in the Zambezi region follow the learning objectives outlined in the subjects' curricula?"

The Ministry of Education (2015) reported disappointing National Examination results for Grade 12 Biology and Physical Science Namibia Senior Secondary

Certificate [NSSC] Ordinary Level, and revealed that in 2014, 2015 and 2016, Grade 12 learners' performances in the subjects in the Zambezi Region were very poor, with very high numbers of learners obtaining E to U symbols (Directorate of National Examinations and Assessment [DNEA], 2015, 2016, 2017); as shown in Table 1 (below).

Table 1: Performance of learners in Biology and Physical Science [NSSC] Ordinary Level examinations of 10 schools in Zambezi Region from 2014 to 2016

Schools	2014		2015		2016	
	Biology	P. Science	Biology	P. Science	Biology	P. Science
A	32.18	37.4	41.1	52.3	35.5	48.6
B	38.5	49.0	29.0	35.2	40.3	45.0
C	38.6	42.9	35.6	53.0	41.3	52.9
D	37.9	34.3	36.2	37.7	38.1	44.0
E	41.3	38.5	34.2	36.2	27.9	25.3
F	38.8	43.1	40.8	45.8	39.9	49.6
G	25.6	38.2	36.0	45.7	40.0	48.9
H	24.3	39.2	47.8	51.2	26.4	56.9
I	28.4	38.5	31.0	45.2	42.9	52.0
J			34.5	33.2	27.1	42.8

DNEA, 2015; 2016 and 2017

Table 1 shows disappointing national Examination results for Grade 12 from 2014 to 2016. According to Ministry of Education (2014), the learners' performance was very poor and that the teaching of practical work in senior secondary schools must be examined to understand how teachers teach and assess.

The need to improve the teaching of practical work so that learners develop scientific skill has been the yearning of the scientific community. Such efforts have been made in the United Kingdom (Millar, 2004). It is against this background that this study sought to investigate the teaching of practical works in Biology and Physical Science in the senior secondary schools in Zambezi region, Namibia.

1.2 Statement of the problem

The current situation of teaching Biology and Physical Science practical works in Namibia is a concern to all including the government. Research suggests that poor teaching among other factors limit the learning of scientific skills in schools (Nakanyala, 2015). According to Ministry of Education (2015 and 2016), the Examiners' reports on Biology and Physical Science Paper 3 (Applied practical skills) shows that learners in the Zambezi region perform poorly in practical works in comparison to Paper 1 (Multiple choice) and Paper 2 (Structured questions). The Examiners' reports further indicated that it is clear from learners' answers that only a few senior secondary schools seem to teach practical work in Biology and Physical Science.

Nghipandulwa (2011) noted that science practical works, in most Namibian schools, is a dream as few science teachers seem capable of teaching practical work. Moreover, practical work assessment has been criticised as inadequate as it fails to assess learners' practical skills. Thus, learners fail to relate their practical experiences to aspects tested in the final examination.

Therefore, it becomes expedient to investigate and establish whether or not the teaching of Biology and Physical Science practical work in senior secondary schools in the Zambezi region follow the learning objectives outline in the subjects' curricula

and suggest appropriate measures that can improve the teaching of practical work in the subjects.

1.3 Research questions

Research questions provide a framework to help the researcher organize the study in order to give it direction, coherence, and relevance (Onwuegbuzie & Leech, 2006). The following questions guided this study:

1. Did the teaching of Biology and Physical Science practical works in senior secondary schools in the Zambezi Region follow the learning objectives outlined in the subjects' curricula?
2. What methods do teachers use in teaching practical work in Biology and Physical science?
3. What practical skills do the Biology and Physical Science teachers aim to achieve from the practical works being taught in the senior secondary schools?
4. What assessment criteria are used by the Biology and Physical Science teachers to assess the practical skills acquired by the learners?
5. What are the opinions of the Biology and Physical Science teachers on the things that should be done to improve the teaching of Biology and Physical Science practical works in senior secondary schools in the Zambezi region?

1.4 Significant of the study

The findings of this study will help Biology and Physical Science teachers to determine whether the practical works they teach in their classrooms follow and achieve the learning objectives of practical works outlined in the subjects' syllabuses, help learners develop practical skills, and relate their practical

experiences to the final written practical examination (Paper 3). The findings of this study might also contribute to new knowledge that might provide grounds for further research.

1.5 Limitation of the study

Limitations are possible weaknesses and shortcomings that the researcher identified during the research study (Pajares, 2007). The limitations for this study were: Firstly, this study was carried out with the Grade 12 Biology and Physical Science teachers at selected senior secondary schools in the Zambezi Region in Namibia. Therefore, the results of this study can only be generalised to the schools with similar characteristics. In Namibia no studies has been carried out in the area of this study. This limited the researcher with regard to literature review because most of literatures reviewed are from outside Namibia. To minimize this limitation the researcher used literature most relevant to Namibia.

The presence of the researcher in the classroom during lesson observation could have affected the teaching mode of the teachers as well as learners' behaviours. Thus, the researcher assured the teachers to teach as they normally do. Another limitation is that the teachers might just do practicals when the researcher is present to give the impression that they often carry out practicals. Thus, the researcher asked for the records of past practical work from the participating teachers to study them and compared the learning objectives with those outlined in the subjects' curricula.

1.6 Delimitation of the study

This study focussed on investigating the teaching of Biology and Physical Science in ten selected senior secondary schools that offered Grade 12 Biology and Physical Science Ordinary Level in the Zambezi Region only.

1.7 Definition of terms

It is important to describe terms that could be misunderstood in order to establish a frame of reference in which the researcher approached the problem (Best & Kahn, 1998). For terms and concepts to carry any meaning that relates to the study they need to be clearly defined. Hence, the following terms should be understood as defined here:

Assessment: This is viewed as the process of determining learners' achievement through assignments, tests, projects and examinations (Linquanti, 2014).

Formative Assessment: In this study, it refers to assessment used during the lessons to help adjust, shape and direct teaching and learning progress with the intent of better meeting the needs of the learners (Popham, 2006).

Summative assessment: this refers to the assessment done to sum up the progress and achievement of learners throughout the year

Achievement: This is the academic performance of a learner measured by the school through test and examinations.

Practical works: Any teaching and learning activity which involves learners observing or manipulating real objects and materials, extracting information from complex systems, testing hypotheses, analysing and evaluating variable data, demonstrations, discussions, simulations and exercises (Millar, 2004; Abraham & Miller, 2008; Le Marechal & Tiberghien, 1999; The Society of Biology, 2004).

Complete observer: It involves merely watching what is happening and recording events on the spot and no interaction occurred between the observer and the observed (Creswell, 2006).

Poor Performance: Refers to the un-accomplishment of practical skills measured against the assessment objectives and the achievement of below 40% in practical works (Lunetta et.al, 2007).

Practical skills: An individual's competency and process skills acquired while performing a scientific activity (Bennet & Kennedy 2001).

Constructivism: Constructivism is a teaching referent and learning theory which regard a science laboratory or classroom as a construction site (Roth, 1995). From a constructivist perspective, teachers are expected to socially engage learners in what they are teaching during practical tasks (Leach & Scott, 2000).

Social constructivism: Social constructivism is concerned with the acquisition of skills through social interactions. Teaching is seen as facilitating and providing opportunities where learners are able to mediate and construct meaning of what they are taught through practical works and socially constructed teaching and learning tools that are used to distribute scientific knowledge (Liang & Gabel, 2005).

Validity: Refers to the degree to which an instrument measures what it is supposed to measure (Kothari, 2004).

Reliability: Refers to the measure of the degree to which a research instrument yields consistent results or data after repeated trials (Kothari, 2004).

1.8 Summary

This chapter introduced the orientation of the study on the teaching of Biology and Physical Science practical works in senior secondary schools. The research problem, research questions, significance of the study, limitations and delimitations of the study, as well as definitions of the terms were highlighted. The next chapter provides the theoretical framework as well as the literature review relevant to the research focus.

CHAPTER 2

THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1 Introduction

This chapter presents the theoretical framework on which this study was based and a review of literature with the purpose to provide what has already been researched on the teaching of Biology and Physical Science practical work. The chapter also discusses the teaching methods that can promote the teaching of practical work in senior secondary Biology and Physical Science, as well as strategies to improve the teaching of practical work in senior secondary schools in Namibia.

2.2 Theoretical framework

A theoretical framework is a concise description of the major variables operating within the arena of the problem to be pursued together with the researcher's overarching view of how the variables interact to produce a more powerful or comprehensive model of relevant phenomena that has not been available for shedding light on the problem (Badugela, 2012). A theoretical framework provides the focus for the study as well as helps the researcher from pursuing shadows rather than reality (Schurink, 1998).

This study is informed and built on the social constructivist theory of teaching and learning (Vygostsky, 1978), which explains that knowledge as a human product is socially constructed. The emphasis of the social constructivist is that the teacher is not a person who is responsible for constructing knowledge for the learners but rather is responsible for providing learners with challenging activities that promote higher level thinking during classroom instruction (Nghipandulwa, 2011). The teacher's role is that of a facilitator, provocateur, creator of opportunity and co-developer of

understanding with learners. Thus, the teacher enters into dialogue with the learners, trying to share the meaning of the materials learned, and to help the learners aquire practical skills (Ritchie and Rigano, 1996). In the most general sense, the teacher encourages learners to use active techniques (experiments, real-world problem solving) to create more knowledge and then to reflect on and talk about what they are doing and how their understanding is changing. The teacher makes sure the learners' prior conceptions are understood, and guides the activity to address them and then build on them.

According to Gray (1997), constructivist teaching is based on the assumption that learning occurs when learners are actively involved in a process of meaning and knowledge construction as opposed to passively receiving information. For Gray, 1997, p.316) "Constructivist teaching fosters critical thinking, and creates motivated and independent learners''. Thus, learners are the makers of meaning and knowledge.

This theory, therefore, fits the purpose of this study, in investigating the teaching of Biology and Physical Science practical work with emphasis on what a teacher can do to help learners to work independently. The important issue then becomes which constructivist approaches to teaching the teachers are using to assist the learners to develop and acquire practical skills and perform better in the final practical examination (Paper 3)? The use of teaching approaches such as learner-centred, activity based, experimentation, small-group discussions, simulations, fieldtrips, group work and problem-based learning might allow learners to engage in social interactions which will promote critical thinking as well as creativity to bring about

practical skills development in Biology and Physical Science. The instructional practices of the Biology and Physical Science teachers should therefore assist learners to acquire the process skills (Ritchie and Rigano, 1996). This theory of social constructivism forms the basis of this study because when the teachers teach the desired and relevant practical works, learners might discover, transform information, construct their own conceptualization, develop practical skills and perform better in practical examinations (Vygostsky, 1978).

2.3 Literature review

This section presents a review of research literature to the teaching of Biology and Physical Science practical works in senior secondary schools in the Zambezi Region, Namibia.

2.3.1 The concept of teaching practical work

The understanding of how teachers teach has evolved, leading to a redefinition of the teaching of practical works (Millar, 2004). Currently, the theories of learning are connected to understanding how teachers teach and teaching of practical work has now been accepted as teachers facilitating learning rather than to be a source of all knowledge in the classroom (Killen, 2013). Teaching practical work involves creating, enriching, maintaining and adapting instruction to achieve the objectives of the subject, capture and sustain interest and engage learners building biological and physical understanding, engaging learners in the process of science that have been systematically tested and shown to reach diverse learners (Millar, 2004). This means that teachers should help learners to construct their own understanding rather than giving them what they expect learners to know (Eunice, Khatete & Ondigi, 2014).

Teaching practical work has been defined in many different ways; for example, Millar (2004) defined it as any teaching activity which involves the learners in observing; manipulating the objects and materials they are studying and testing of a prior hypothesis. Eunice et al (2014), on the other hand define practical work as being logical instruction that focus on knowledge, concepts and a range of skills that learners are to acquire on their own with the guidance from their teachers. Therefore, the teacher's role is to facilitate the attainment of skills by the learners by using different methods of teaching, such as problem-based teaching, group work and practical activities that allows learners to develop practical skills. The teacher should expose learners to situations where their ideas are matched against the biological and Physical Science concepts, which are backed up by evidence through experimentation (Nghipandulwa, 2011). This may lead the learners to better understand Biological and Physical Science concepts and hence perform better in practical examinations.

Other research into the teaching of science (OECD,1994; Shulman, 1986) further indicate that science teachers' role is to manage group work effectively; incorporate practical work in their teaching; use multiple methods of teaching to ensure that learners acquire practical skills; and improvise their teaching. Increasingly, the teacher's role involves being a mentor who guides learners' deep understandings, and also one who facilitates learners' acquisition of higher order thinking and practical skills (Abell & Pizzini, 1992). Basically, teachers of science are facilitators, co-operators, collaborators and mediators between learners and what they need to know, and creators of favourable learning environments (Crawford, 2000). Therefore, science teachers are those who engage learners in experimental and

investigative skills, who promote social construct learning, and nurture collaborative classroom practices among learners (Abell & Pizzini, 1992).

2.3.2 Importance of teaching practical work in science

The value of teaching practical work has been recognised at the senior secondary level. Many teachers acknowledge the importance of teaching practical work because learners learn by doing rather than being told or shown (Nghipandulwa, 2011). If learners are taught practical works in Biology and Physical Science, then this could help them understand the contents well and will remember what they have done with their hands. This was further emphasized by Hodson (1990) who stated that practical work teaching is an important component of science subjects. He suggests five reasons for teaching practical works and involving learners in practical activities, namely: to teach practical skills, motivate interest in science, develop scientific attitudes, enhance learning of scientific knowledge and to give insight into scientific method (Hodson, 1990).

Teaching practical works should have a purpose of engaging learners in worthwhile activities and should not simply teach learners skills irrespective of whether or not they are needed for future learning (Kandjeo-Marenga, 2008). Hodson (1996) argues that the purpose of teaching practical work should be considered as helping the learners to acquire practical skills. It is therefore important that teachers prepare learners with mastery of the skills required so that they will be ready for practical examinations. Hodson (1996) further added that through practical work the learners carry out certain activities to test a hypothesis, to discover something as yet unknown and to check facts that are already known. In order for the learners to carry out these activities, the teacher has to teach the required skills for practical work, which

includes observing, recording, doing experiments and interpreting the results obtained.

According to Gott and Duncan (2003), teaching practical work is an approach that develops procedural understanding, allows learning by doing and provides opportunities for learners to touch and hold equipments themselves rather than being taught theoretically. Practical work would thus enable learners to do science using the ways of scientific inquiry. Furthermore, teaching practical work is meant to stimulate the development of analytical and critical skills and create interest in science (Ottander & Grelsson, 2006). For the interest of learners in Biology and Physical Science to be increased and for them to become motivated to do science, it is importance that the teachers teach and perform practical work with them.

Teaching practical work with real objects and materials help both teachers and learners to communicate ideas and information about the natural world, and also provide opportunities to develop learners' practical skills of the scientific approach to enquiry (Nghipandulwa, 2011). Teaching practical works in schools is essential to train learners to become scientists and is helpful in concept learning, attitude development and interest in Biology and Physical Science. Practical work give the learners the appreciation of the method of science, promotes problem-solving and gaining understanding of the nature of science (Ausubel and Novak, 1968). The teaching of practical work in science subjects such Biology and Physical Science is widely accepted and it is acknowledged that it promotes the engagement and interest of learners as well as developing a range of skills, subject knowledge and conceptual understanding (Kasanda, Kapenda, Kandjeo-Marenga, and !Gaoseb, 2001).

According to Adegbamigbe (2002), teaching practical work consist of a series of dynamic processes and activities that encourage inquiry and hands-on experiences within the classroom with a view to enhance learning, promote development of practical skills and learners' achievement. Well planned and effectively implemented science practical work stimulates and engages learners' at varying levels of inquiry (Millar, 2004). The Biosciences Federation (2005), reports that poor teaching of practical work may cause an impediment to learners' attitude toward science. Learners' exposure to practical work do not necessarily imply improving their scientific knowledge (Kahn, 2000). What counts is how practical work is taught to help learners develop the understanding of scientific concepts, practical skills and to carry out scientific investigations (Hodson, 1993).

Schmidt, Marohn, and Harrison (1999) describe science teachers as being obsessed with teaching unrelated tasks and activities and described the practical teaching as being low in assisting learners acquire practical skills. The Royal Society of Chemistry (2006) states that the issue that might put learners off from continuing with science is how practical work is taught in schools. Most investigations are presumed narrow in range and sharply concentrated on the perceived demands of assessment (Bennett & Kennedy, 2001).

Science is about seeing is believing (Ausubel et al. 1968). So learners should see for them to believe, not only taught facts without any supporting evidence. Learners for that matter need proper teaching and guidance in carrying out practical work.

It is therefore, important that learners are taught practical work in Biology and Physical Science in order for them to benefit from those practicals and be able to

understand Biology and Physical Science better. Teachers should prepare, organise and teach practicals, and then help learners to do the practicals themselves if the learners are to benefit from the teaching of practical work and acquire the skills taught.

2.3.3 Teaching of Biology and Physical Science Practical work

The science curriculum requires the teaching of practical skills, and learners are to learn these skill. The curriculum is divided into three domains. Domain C deals with practical (experimental and investigative) skills and abilities, and indicates the intended learning outcomes for practical work. The practical skills in Biology and Physical Science are intended to equip learners with skills to: use appropriate techniques; handle apparatus; measure and record estimates accurately, handle and process experimental observations and data, apply scientific knowledge and understanding to make interpretations and draw appropriate conclusions from practical observations and data; plan, design and carry out investigations and suggest modifications in the light of experience (Ministry of Education, 2009).

Teaching practical work involves creating, enriching, maintaining and adapting instruction to achieve the objectives of the subject, capture and sustain interest and engage learners in building biological and physical understanding (Millar, 2004). Teachers have a wide variety of teaching strategies at their discretion, which differs in terms of the amount of teachers' preparation and the number and learning objectives to be taught and achieved (Gastel, 1991). The teacher should expose learners to situations where their ideas are matched against scientific concepts, which are backed up by evidence through experimentation and investigation, and therefore the learners has to justify their ideas against scientific observations (Beck and Earl,

2003). This leads to better understanding of the scientific concepts and greater achievement in Biology and Physical Science. Teachers are supposed to develop teaching methods that allow for increased opportunity for practical activities. This is because learners tend to learn more when they are engaged in practical activities.

According to Killen (2013), for teaching to take place in the classroom, the teacher is expected to act as a facilitator in the teaching process, while the learners interact in groups, solving problems by undertaking practical work in order to consolidate what they have learned in real-life situations. Teaching needs to focus on the range of knowledge, concepts and skills that learners are not yet ready to acquire on their own but can acquire with the help from their teachers.

The Qualification and Curriculum Authority (2007) asserts that teaching practical work is the key to enhance learning, and consolidation of theory, while Hofstein and Lunetta (2004) describe teaching practical work as enabling learners to apply their knowledge of science in investigative situations. The teaching of practical skills in senior secondary schools, especially in the Zambezi Region seems problematic as learners continue to perform poorly in the Namibia Senior Secondary Certificate (NSSC) practical examination (Ministry of Education, 2009). In fact, Millar (2004) argues that few teachers use the practical approach in their teaching. Thus, the teaching of practical work in secondary schools requires relevant researches with a view to identifying shortcomings and improving the practice.

2.3.4 Teaching methods for Biology and Physical Science practical work

Teaching methods are the most important techniques employed by teachers to realize the objectives of a lesson (Borich, 2007). Thus, teachers of all disciplines including

Biology and Physical Science use various teaching methods for achieving lesson objectives. For Biology and Physical Science learners to achieve their full potential, it would be essential fort teachers to engage in using effective teaching methods (Borich, 2007). Al Maghraby and Alshami (2013) state that science teachers need to use teaching methods which are flexible, creative, and more learner-centred, in order to accommodate different learning styles of learners. Teachers should employ teaching methods which provide opportunities to learners to learn sharing knowledge and providing sufficient exposure of what they expect in the examinations. This could be done by giving learners more problems to work on and chances to learn the subject content in real-life situations through undertaking practical work in the laboratory.

Fishburne and Hickson (2001), however, propose that appropriate teaching and learning methods in science, such as group work, laboratory investigations and problem–based teaching, allow learners to interact and help each other to attain better subject understanding and achieve practical skills. The use of different teaching methods is likely to accommodate different individual learning styles among the learners. Khoboli and O‟Toole (2011) argue that the teachers' commitment to constructive learner methods does not mean that all the practical skills are achieved with such methods, but that the choice of teaching methods should depend on the objectives of a practical lesson to be covered, the resources and time available.

According to Mawazo (2010), the use of inappropriate and ineffective methods such as lecturing, copying materials in notebooks, heavy testing through factual questions, make the teaching of science very boring to learners. Mawazo (2010), state that these

are some of the methods that are also employed by Biology and Physical Science teachers in their classrooms. Shadrack and Isaac (2012), however, propose that one way teachers can promote the teaching of practical work in their classroom is by using the constructive learner method using different interesting methods and incorporating practical activities in their lessons. It is thus assumed that the use of a variety of teaching methods in the teaching of practical work has more advantages, such as enhancing learners' attention and interest, as well as giving teachers the flexibility to be able to work with a wide range of challenges encountered in the teaching and learning process, rather than using one type of teaching method (Pretty, 2009).

According to Bajah and Asim (2002), guided-discovery is a better approach to acquisition of knowledge when teaching practical work than conventional methods such as lectures. If it is properly implemented, guided-discovery can lead to increased motivation to learn, greater retention of knowledge, deeper understanding, and achievement of practical skills (Froyd & Simpson, 2008). Garcia (2003) noted that science in many schools is still being taught primarily through the lecture method and textbooks, rather than through exploration and experimentation which would allow learners to construct their own knowledge. In other words, some teachers in secondary schools are still not aware of what impact some teaching methods have on the teaching and learning of science (Garcia, 2003).

The following teaching methods, discussed below, are considered to provide opportunities for learners to work under a more constructivist environment that can enhance the learners' active role in learning science and acquisition of practical skills.

2.3.4.1 Group experiments

Group experiments are considered the hallmark of practical work teaching as teachers usually relate to the actual manipulation of apparatus and equipments (Tifi, Natale, & Lombardi, 2006). According to Hodson (1993), group experiments gives learners the opportunity to communicate with one another and to some extent, they might also interact with their teachers. He further states that in group experiments, learners apply the methods, principles and concepts that they are being taught in their lessons and learners who do not contribute to the full class are allowed a platform on which to make contributions to a group. Group experiments can allow learners active engagement in the construction of scientific knowledge and skills as well as in using science tools. Thus, learners become involved in task oriented talking and meaning-making is negotiated socially (Hodson, 1993).

Kandjeo-Marenga (2011) states that when learners work in groups they help each other, provide suggestions, explanations, question others, signal to others what next step needed to be taken, and exchange views as they try to solve problems. Group experiments can also provide an opportunity to learners to restructure their own thinking skills through interactions with peers (Muijs & Reynolds, 2011).

The use of group experiments by Biology and Physical Science teachers can help learners in carrying out procedures, manipulating materials and apparatus as well as performing of practical skills.

2.3.4.2 Investigations

Investigations may be perceived as practical work that are carried out and involves testing of a hypothesis or solving a problem (Hofstein & Mamlok-Naaman, 2007). Testing a hypothesis may involve hands on activities in the laboratory or in the field

including making observations and collecting data to be able to make generalizations (Bradley, 1999). Investigating, testing and making observations fits very well with the teaching of practical work. Testing a hypothesis is in fact part of the scientific method that learners can adopt in trying to verify what they have been taught and solve problems (Gauch, 2003). It has been asserted that teachers should teach practical work through investigations as it helps learners to develop practical skills (Hamilton & Swortzel, 2007). It also allows learners to master the skill of making scientific observations and making scientific conclusions based on evidence which is the essence of practical work in Biology and Physical Science. However, it has been argued that science teachers have to be well versed with such practical work to effectively help their learners appreciate the importance of gaining such skills (McLoughlan, 2007).

2.3.4.3 Teacher demonstrations

Demonstrations are a form of practical work that science teachers can use to teach certain skills to their learners (Woodley, 2009). Some studies have suggested that demonstrations can be categorized into visual aids using non-conventional apparatus, analogue demonstrations and real experiments (Erlis & Subramaniam, 2004). Demonstrations as a form of practical work can benefit learners in many ways including encouraging inclusiveness (Meyer, Schmidt, Nozawa, & Paneee, 2003). Demonstration can be an important and effective form of teaching practical work in situations where practical work resources are scarce or when class sizes are too large (Hayward, 2003). However, other studies argue that demonstrations are just a waste of time and resources because learners are not socially and actively engaged in actual manipulations and hands on activities (Swanson, 2000).

2.3.4.4 Fieldwork

Fieldwork may consist of range of activities such as observations of natural and physical phenomena like plants and animals in a forest, visiting a park or zoo (Eberbach & Crowley, 2009). The importance of teaching this type of practical work is that it enables learners to have a wider perspective about the nature of practical work activities and that they are not limited to laboratory organized tasks (Tunnicliffe, 2000). The other advantage of teaching outdoor practical activities is that it allows learners to actively engage in making observations, thinking process, organizing and managing the whole practical active (Abrahamsa & Millar, 2008). Field-work can also motivate learners especially when they investigate live specimens including plants and animals and when they are actively involved in making observations. However, some studies cautioned that such activities have to be properly planned, monitored and supervised to ensure that the activities fulfil their objectives (Powera, Taylora, Reesa, & Jonesb, 2009).

2.4 Problems affecting the teaching of practical work

Kapenda (2008), states that in some Namibian senior secondary schools, teachers mostly use the lecture method which does not give learners opportunities to interact and enhance their understanding. In some schools, teachers are unable to apply different teaching methods, due to factors, such as the unavailability of chemicals, equipment, apparatus and laboratories.

In another submission, Kandjeo-Marenga (2011) points out that most Namibian secondary school science teachers find it difficult to teach practical work due to lack of laboratories, thus forcing teachers to teach using demonstration methods rather than experiments in teaching practical work. According to Muijs and Reynolds (2011), there are teaching factors that seem to be associated with learners' positive

learning outcomes, for example, stating basic competencies clearly; an emphasis upon the lesson introduction; teacher's good subject knowledge; good questioning skills; good time management; effective lesson planning and good classroom management. Teachers who have many of the aforementioned qualities may lead their learners to achieve scientific skills.

Muijs and Reynolds (2011), further state that if teachers allow social interactions, facilitate learning and apply different teaching methods in their classroom, there might be improvement in the understanding and acquiring of skills by learners. Jacobs, Vakalisa and Gawe (2004) argue that the teaching of practical work depends on how science teachers create and maintain a good teaching and learning environment in their classrooms. This could be achieved if the teacher knows how to prepare and organise the laboratory as well as maintain a high level of discipline among learners during practical activities.

However, the lack of chemicals, equipments, materials and apparatus, are among the commonly perceived factors affecting the teaching of practical work (Jacobs, Vakalisa, & Gawe, 2004). According to Synder and Viogts (1998), the unavailability of teaching and learning materials in schools, such as laboratory manuals, textbooks, chemicals, apparatus and equipment, has a negative impact on teaching practical work. They further state that, for some schools resources might be sufficient, but teachers are not using them. Some teachers lack the necessary expertise in how to use certain apparatus and equipments in teaching practical work. However, the available resources at some schools are inappropriate for teaching practical work (Synder, & Viogts, 1998).

Jacobs, Vakalisa and Gawe (2011) state that it is important for the science teacher to have knowledge on how to facilitate practical work, because it is not enough for a teacher to know suggested practicals in the subject's syllabus without the knowledge of how they conducted. This type of knowledge helps the teacher to draw up practical activities for learners as well as to prepare and set appropriate materials and equipments for learners who have to carry out the experiments. According to Hill (2014), schools need teachers who are knowledgeable and have teaching experience as well as courage to facilitate practicals. In addition, Hill (2014) states that teaching should not only be a matter of facilitating learning in which learners are expected to acquire new knowledge, but should also be a practical experience that can assist learners, create their own knowledge and enhance their practical skills.

According to Likoko, Mutsotso and Nasongo (2013), the teaching of practical work cannot take place if basic experimental resources are not available in laboratories. The availability of practical materials and facilities in the laboratories are important for teaching practical skills. They further argue that learners' performance in practical examinations can be affected by the quality and number of teaching resources. However, in schools with adequate facilities the learners tend to perform well in examinations compared to the poorly equipped schools (Likoko et al., 2013).
On the other hand, Folashade and Akinbobola (2009) are convinced that the inappropriate use of teaching method in science classrooms, large class size, lack of sufficient funds, improper monitoring, and lack of standard laboratory equipment are among the main factors considered to be affecting the teaching of practical work in schools. They further state that the teacher's ability to teach practical depends on the teaching methods the teacher uses. Therefore, it is assumed by Folashade and

Akinbobola (2009), that when the teachers use appropriate teaching methods this might promote the performance of learners. In addition, Mji and Makgato (2006) note that the other factor affecting the teaching of practical work in schools relate to the use of the laboratory including the creation of a teaching and learning environment that encompasses teachers' pedagogical knowledge in the classrooms. According to Garcia (2003), teacher's negative attitude about science is a possible hindrance to the teaching of practical work in the school setting.

2.5 Formative assessment of practical skills

Teachers are required to devise schemes to assess and record achievement in experimental skills (Ministry of Education, 2009). However, concerns have been raised about the extent to which assessment of practical skills dominates teaching and learning in science (Lunetta, Giddings & Hofstein, 2007). This raises the question of assessment criteria used by Biology and Physical Science teachers to assess practical skills (Ministry of Education, 2009). According to the Ministry of Education (2009), assessment of practical skills in most secondary schools seems to make use of written task where learners complete a test paper that includes questions about practical work under examination condition and reports on investigations using data that have been provided. With this kind of practice, assessment of the actual practical skills learners are expected to acquire will only be based on theoretical knowledge which the learners may not be able to apply in real life situation. Furthermore, the science teachers may also result to theoretical and tailor-made teaching of the practical work just to enable the learners answer questions given as an alternative to actual practical experiment to be performed.

2.6 Role of formative assessment in the teaching of Practical work

Black and William (2002) revealed a significant positive role formative assessment can play in the teaching and learning process when done well and according to policy. Concurring, Willis (2009) points out that formative assessment informs both teachers and learners about the teaching process and learning progress. Therefore, formative assessment can be used to enhance teaching and improve active engagement of learners during science practical activities.

Researchers such as Hodgson (2010), Linquanti (2014), and Thomas (2012) agree that formative assessment can improve the quality of teaching practical work and improve learners learning. Bell and Cowie (2001) accentuate that the role of formative assessment can be viewed as the process by which science teachers gather assessment information about the learners' learning with a view to engage in remedial teaching. Jones (2005) points out that formative assessment is all about informing teachers about learners' progress and to empower them to take the necessary action to improve their performance. Concurring, Rashid and Jaidin (2014) posit that formative assessment provides an avenue for teachers to give feedback on the learners' performance and achievement of skills during each lesson. Leahy, Lyon, Thompson and William (2005) explain that formative assessment involves teachers adjusting their teaching strategies. They came up with a set of strategies as the starting point of assessing practical skills namely: Clarifying and sharing practical objectives and criteria for assessment; facilitating practical work discussions and practical tasks; and providing feedback that assist learners acquire the necessary skills.

2.7 Assessment criteria of practical skills in biology and physical science

For Biology and Physical Science teachers to assess practical skills during the teaching of practical work, the Biology and Physical Science syllabi (Ministry of Education, 2009) articulates the use of assessment criteria based on the principle of positive achievement, which means that the focus is on what the learners understand and can do (Ministry of education, 2009). In Wilmot's view, the purpose of assessment criteria is to collect information on "how well a learner is performing in relation to practical goals" (Wilmot, 2003, p.56). In this sense, assessment in Biology and Physical Science is also criteria-based.

Kelly (1989, p.23) pointed out that "the clearer the teachers are about the objectives, the easier it is for them to identify criteria for assessment". Brown and Knight (1994) argued that assessment is fair and reasonable if criteria are shared with the learners. These criteria are explicated in the NSSCO Biology and Physical Science syllabi. The syllabi suggest that each skill or attitude must be assessed on a 6 point scale, level 6 being the highest level of achievement. Each of the skills is assessed in terms of three levels of achievement at scores 2, 4 and 6. Marks (1-6) should be awarded for each of the experimental skills in terms of the performance criteria presented in the Table 2 below:

Table 2: Criteria for the assessment of practical skills and abilities

	Practical (Experimental and investigative) Skills and Abilities	**Marks**
Skill C1	• Follow sequence of instructions; • Use appropriate techniques; • Handle apparatus and materials competently; • Have regard for safety.	1 or 2 3 or 4 5 or 6
Skill C2	• Make and record estimates; • Make and record observations;	1 or 2 3 or 4

	• Make and record measurements accurately	5 or 6
Skill C3	• Handle and process experimental observations • Handle and process experimental data • Deal with anomalous or inconsistent results	1 or 2 3 or 4 5 or 6
Skill C4	• Apply scientific knowledge and understanding to make interpretation from practical observations and data • Apply scientific knowledge and understanding to draw appropriate conclusions from practical observations and data	1 or 2 3 or 4 5 or 6
Skill C5	• Plan, design and carry out investigations • Suggest modifications in the light of experiences	1 or 2 3 or 4 5 or 6

Source: Ministry of Education, 2008, 2009

Nitko (1996) argues that if teachers teach their learners what is expected during practical work and learners know on what criteria they will be assessed, the teacher will improve both his teaching and the assessment methods.

Nitko (1996) proposes scoring rubrics for assessing practical skills. Formative assessment policies assume that when specific criteria or a scoring rubric are used, the fairness and reliability of the assessment activity will increase. Brown and Knight (1994) also express this view when they argue that assessment is fairer if criteria are devised and used. According to Orwa and Underwood (1986), assessment criteria need to be devised to measure mastery of content, performance in practical skills and development of desirable scientific attitudes. According to Yung (2001), one of the reasons for lack of proper assessment criteria is that teachers lack experience with assessment methods aimed at assessing their learners' performance of practical skills. As a result teachers fail to devise schemes to assess and record achievement in experimental skills.

2.8 Summary

This chapter has presented the theoretical framework that provided the focus for the study and helped in setting a clear picture on how practical work could be taught during classroom or laboratory instruction, namely the theory of Social Constructivist (Vygotsky, 1978), that emphasises that the teacher is not a person who is responsible for constructing knowledge for the learners but rather is responsible for facilitating and providing learners with challenging practical activities that promote higher order thinking during classroom instruction. The chapter also provided a review of relevant literature on how scholars have defined the concept of teaching practical work; the teaching methods considered in promoting the teaching of Biology and Physical Science practical work such as group experiments, investigations, teacher demonstrations and fieldwork. In addition, problems affecting the teaching of practical work were reviewed. Finally, literature was reviewed on formative assessment of practical skills, the role of formative assessment and assessment criteria of practical work. The next chapter outlines and describes the research methodology used in this study.

CHAPTER 3

RESEARCH METHODOLOGY

3.1. Introduction

This chapter outlines the methodology used in the study to investigate the teaching of Biology and Physical Science practical work in senior secondary schools in the Zambezi Region, Namibia. The researcher described the research design that was followed in order to gather data, the population, the sample and sampling procedures, research instruments, data collection procedures, pilot study and data analysis. The ethical considerations followed to collect data were also outlined in this chapter.

3.2 Research design

According to Goodwin and Goodwin (1996), a research design involves the most effective strategy for finding the information most appropriate to answering the research questions. This study used a mixed methods research design that involved the collection and analysis of both qualitative and quantitative data in order to provide a comprehensive analysis of the study (Creswell, 2006).

The quantitative method employed structured questionnaires and document analysis to obtain data on whether the teaching of Biology and Physical Science practical work in senior secondary schools in the Zambezi Region followed the stipulated learning objectives, and the assessment criteria used to assess the practical skills acquired by the learners. The qualitative method, on the other hand, used lesson observations to complement to data collected from the questionnaire. Follow up interviews were conducted to collect data on the skills science teachers aimed to achieve when teaching practical work.

3.3 Population

Creswell (2006) defined a population as a group of people with common characteristics in which the researcher is interested in studying and from which the study sample is taken for investigation. The target population of the study consisted of all Biology and Physical Science teachers in the ten Senior Secondary Schools in the Zambezi Region. There were a total of 24 Biology and Physical Science teachers in the schools (Ministry of Education, 2014). The researcher chose the Biology and Physical Science teachers since they were assumed to be rich in information to answer the researcher's questions.

3.4 Sample and sampling procedure

Creswell (2006) defined a sample as a finite set of respondents selected from a population to provide the information required to answer the research questions. The sample of this study consisted of 7 Biology teachers and 7 Physical Science teachers selected from all the senior secondary Biology and Physical Science teachers in the Zambezi Region. The teachers were selected using the purposive sampling method. This sampling method was deemed necessary because it enabled the researcher to select participants who are actually teaching Biology and Physical Science in the study area. Cohen, Manion, and Morrison (2007), state that purposeful sampling is used in order to access knowledgeable people who have in-depth knowledge about particular issues. They concur with Creswell (2012) who says in purposeful sampling the researcher intentionally selects individuals to learn or understand the central phenomenon.

Extreme case criterion was used in selecting the sample. To achieve this, each participating teacher must teach Biology or Physical Science in the study area for at least three consecutive years.

This category of teachers were selected because they were thought to have sufficient experience of teaching practical work of Biology and Physical Science and could comprehensively respond to the research questions.

The purposive sampling method used to select a subsample of 3 Biology and 2 Physical Science teachers from among the Biology and Physical Science teachers who completed the questionnaires to participate in the lesson observation and interviews. To form part of the sub-sample that participated in the lesson observation and interview, the teacher must have participated in filling the questionnaire, be available and willing to be observed and interviewed. The pseudo-names of the teachers and their schools are given in the table below. .

Table 3: The schools and teachers who participated in the study

Schools	Biology Teacher	Physical Science teacher
A	T1	T2
B	T3	T4
C	T5	T6
D	T7	T8
E	T9	T10
F	T11	T12
J	T13	T14

Source: Field data, 2018

3.5 Research instruments

Four types of research instruments were used for collecting data in this study. The instruments included structured questionnaires, observation schedules, interview

schedules and document analysis. These instruments are explained in detail in the following subsection.

3.5.1 Questionnaires

A questionnaire is a self-report data collection instrument that each research participant fills out as part of a research study (Johnston & Christensen, 2008). The questionnaires consisted of five sections comprising of questions on how practical work are taught by the Biology and Physical Science teachers in their respective schools, the types of practical skills the teachers aimed to achieve, how the practical skills are assessed by the teachers, and what assessment criteria are being used to assess the practical skills acquired by the learners. The content validity of the questionnaires was established by having the questionnaire reviewed by my supervisor at the University of Namibia. His comments were incorporated and the questionnaire was then revised before administering to the participants. The questionnaires are given in Appendix 7 & 8.

3.5.2 Lesson observation schedule

Observations are an effective way of watching and gathering live data about the activities and the people who participate in those activities that take place in actual classroom setting (Creswell, 2006). Stake (1995) indicated that, the importance of using observation is to increase understanding of the classroom activities being studied. In other words, observations are an effective or useful way of describing the classroom setting, the activities that take place in that setting, the people who participate in those activities, and capturing the meaning of what is observed from the perspective of those being observed (Patton, 1990).

In this study, five practical lessons (3 Biology practical lessons and 2 Physical Science practical lessons) were observed during normal class hours, from 07h00 to 13h00. The focus during the lesson observation was to understand the teachers' role during the lesson, the teachers' interactions with the learners, the teaching methods used, learners' activities, and the teachers intended practical skills as compared with the practical learning objectives outlined in the subjects' syllabi. The observations also focussed on the physical setting, teaching materials used, and the seating arrangements in the classrooms.

3.5.3 Interviews

The researcher used follow up interviews to collect indepth data from the teachers about the teaching of Biology and Physical Science practical work in their respective schools. The interview guides (see Appendix 11 & 12) consisted of eight open-ended questions. Interviews, according to Millar, Le Marechal, and Tiberghien (1999) are a more intrusive form of data collection procedure that involves asking participants questions, and recording answers. In this study, six face to face interviews were conducted at the end of the lesson observations. The purpose of the interview was to obtain in-depth information on the teaching of the practical work, the practical skills the teachers aimed to achieve, and assessment criteria used by the teachers to assess the practical skills acquired by the learners. The researcher also used the interviews to collect data on the teachers' views about what could be done to improve the teaching of Biology and Physical Science practical work in schools.

3.5.4 Documents (Syllabi, lesson plans, learners' workbooks)

Documents are written text and/or images which provide information and valuable evidence that is associated with events, people and actions studied (Silverman,

2003). Patton (2002) states that documents provide valuable sources of evidence in research, not only because of what can be learned directly from them but because they also stimulate a path of enquiry and can be reviewed repeatedly. The researcher examined and analysed the following documents: NSSC-O level Biology and Physical Science syllabi (2009), lesson plans and learners' workbooks. From the syllabi, the teaching methods proposed to be used to teach practical work were identified. Lesson plans were analysed to note the type of practical work the teachers have been teaching, types of practical skills aimed to be achieved, and the criteria used for the assessment of the practical skills. The learners' work books were analysed to identify the assessment criteria used to assess practical skills.

3.6 Data collection procedure

Data collection for this research study involved five phases. These are enumerated as follows:

Phase 1- Pilot testing of the research instruments: The teacher questionnaires, lesson observation schedules and interview questions were pilot tested with Biology and Physical Science teachers in School G in the Zambezi Region for both the content and construct validity.

Phase 2- Administration of questionnaires: The researcher personally distributed the questionnaires to the 7 Biology and 7 Physical Science teachers in the senior secondary schools. To ensure a high return rate of the questionnaires, the researcher personally collected the completed questionnaires the following day.

Phase 3- Practical lessons observation: The researcher observed 3 Biology practical lessons and 2 Physical Science practical lessons. The researcher assumed the role of a complete observer during the lesson observation by not engaging in interactions with the teachers and learners to avoid unintended influence and to

achieve greater understanding of the activities that took place during the practical sessions. The researcher made field notes of what happened during the practical sessions (Creswell, 2006; Bogdan and Biklen, 2007).

Phase 4– Interviews: Interviews were conducted with four Biology and two Physical Science teachers who indicated their willingness to take part in the interviews. Each teacher was interviewed for 10 minutes. Drawing on McLoughlan (2007), permission was requested from participants to use an audio recorder to obtain interview data and to avoid missing out and losing the teachers comments. All the teachers agreed. The data collection during the interview was tape-recorded using a Samsung Digital Voice Recorder SVR-S820 and transcribed.

Phase 5- Collection of documents from teachers: After lesson observations and interviews, the researcher obtained school curriculum documents for reference on what was observed and said during the interviews and observations. Curriculum documents obtained include: NSSC-Ordinary level Biology and Physical Science syllabi (2009), Biology and Physical Science lesson plans, learners' Biology workbooks and learners' Physical Science workbooks. The documents obtained were indexed and given a code to make it easy for data analysis. The coding systems used for documents are as follows: The Biology syllabus (BS) – D1, Physical Science syllabus (PSS) – D2, Biology lesson plans (BLP) – D5, Physical Science lesson plans (PSLP) – D6, learners Biology workbooks (LWB) – D7 and learners' Physical Science workbooks (LPSWB) – D8.

3.7 Data analysis

Data analysis is the process of making sense and finding meaning in the raw data as well as describing and interpreting what has been seen and what has been said (Gay,

Mills & Airasian, 2006). It entails coding; categorising, ordering, manipulating, summarising, accounting for, as well as explaining gathered data (Brink, 2007). The analysis of data in this study, followed two distinct phases; 1) the quantitative data were analysed using descriptive statistics such as percentages and frequencies (Creswell, 2006) and 2) the qualitative data were analysed using coding and thematic analysis method whereby main incidents or occurrence of responses from teachers were noted and grouped to establish patterns, themes and categories (Creswell, 2009).

Transcribed data was coded by labelling relevant words, phrases, sentences, concepts and opinions before organising them into themes. Coding is described by Merriam (1998) as assigning short hand designation to various aspects of your data so that you can easily retrieve specific pieces of data. Miles and Huberman (1994) express the importance of coding data from interview responses as a way of reducing what is typically called data overload. The data from the documents was analysed by using the document analysis guide (DAG) (Appendix 13).

3.8 Pilot study

A pilot study is a mini-version of a full-scale study or a trial run in preparation for the complete study (Baker, 2002). According to Lancaster, Dodd, and Williamson (2004), a pilot study can reveal deficiencies in the design of a proposed investigation or procedure and these can then be addressed before time. A pilot study was conducted at School G in the Zambezi Region. However, the school was not part of the actual sample used in the main study. The aim of the pilot study was to check the validity and reliability of the research instruments.

According to De Vos and Strydom (2005), a valid research instrument is one that does what it is intended to do. That is, by measuring what it is supposed to measure and yielding scores whose differences reflect the true differences of the variable being measured rather than random or constant errors. According to Kothari (2004), validity of the research instrument can be determined by using a panel of persons who shall judge how well the measuring instrument meets the standards. For this study validity and reliability of the research instruments was tested and ensured by discussing the instruments with the researcher's supervisors in the Department of Mathematics, Science and Sport Education of the University of Namibia. The research instruments (the questionnaire, interview questions and observation schedule) were given to the researcher's supervisors for comments and suggestions before administering them to the participants. The supervisors' comments and suggestions were used to make changes and corrections which were included in the final instruments, and piloted them afterwards in order to determine the reliability.

Reliability refers to the extent to which independent administration of the same instrument consistently yields the same or similar results under comparable conditions (De Vos and Strydom, 2005). During the pilot study, the teachers understood the instruments and answered the questions accordingly. No adjustments were made to the research instruments afterwards.

3.9 Research ethics

Ethics refers to a code of conduct in order to protect an individual's privacy. No researcher has the right to invade the privacy of the subjects involved in his/her study (Christian, 2000; Stake, 2000). In general, the code of ethics attempts to protect research participants and the locations.

The researcher adhered to the following ethical principles, before, during and after data collection:

- Prior to the commencement of this study, a research proposal was submitted to the University of Namibia's School of Postgraduate Studies for approval. Following the approval, the researcher obtained research permission letter from the University of Namibia's Centre for Postgraduate Studies (Appendix 1).
- Then, permission to carry out the study was obtained from the Ministry of Education through the Permanent Secretary, Zambezi regional director of education and the school principals.
- Furthermore, the participants were requested to give their consent to voluntarily participate in the study before administering the instruments. They were assured of confidentiality and anonymity by informing them that no real names of the participants and the schools would be used. The researcher rather formulated codes with which he identified the schools and teachers. The teachers who agreed to take part in the study signed a consent form (Appendix 6 and 7).
- Prior to data collection, all participants were briefed to ensure that they understood that their participation in the study was voluntary, and that they would be observed and interviewed. All the participants were informed that they had the right to withdraw at any time without being penalised or disadvantaged in any way.
- Permission to audio-record the interviews was sought and dully obtained from the participants.

- Collected data were securely stored in the hard drive of which only the researcher had access to and would be kept for a period of two years after the study. Thereafter, the soft copies will be deleted permanently from the hard drive.

3.10 Summary

This chapter outlined the methodology of the study. The research design, population, sample and sampling, data collection instruments as well as data analysis methods employed for the study were described. The chapter ends by describing the ethical considerations taken during the study. The next chapter outlines the results and discussion of the study. Thus, the next chapter provides insight into the teaching of Biology and Physical Science practical work, practical skills science teachers aim to achieve, assessment criteria used to assess practical skills and suggestions to improve the teaching of practical work.

CHAPTER 4

PRESENTATION AND DISCUSSION OF RESULTS

4.1 Introduction

This chapter presents the findings that emerged from the study and the discussions of the results. The main the purpose of the study was to investigate the teaching of Biology and Physical Science practical work in senior secondary schools in the Zambezi region. The results are presented and discussed according to the research questions. Thus, this chapter is divided into four themes which were pre-determined by the research questions, namely:

Theme 1: The teaching of Biology and Physical Science practical work in senior secondary schools in the Zambezi Region vis-à-vis the learning objectives outlined in the subjects' curricula.

Theme 2: Practical skills the Biology and Physical Science teachers aim to achieve from the practical work being taught in the senior secondary schools.

Theme 3: Assessment criteria used by the Biology and Physical Science teachers to assess the practical skills acquired by the learners.

Theme 4: Teachers' views about measures that could improve the teaching of Biology and Physical Science practical work in senior secondary schools in the Zambezi Region.

The final section provides a summary of the chapter.

4.2 Information about participants

4.2.1 Teachers' gender

The percentage gender distribution of teachers is shown in Table 4.

Table 4: Gender distribution of Biology and Physical Science teachers

Gender	Biology	Physical Science	Total	Percentage
Male	5	7	12	85.7
Female	2	0	2	14.3
Total	**7**	**7**	**14**	**100**

Data in Table 4 show that 7 Physical Science teachers and 5 Biology teachers in the study were males. Data in Table 4 also show that 2 Biology teachers in the study were females. There was no female Physical Science teacher in the study.

4.2.2 Teaching experience

The teachers' years of teaching experience is presented in Table 5.

Table 5: Teachers' years of teaching experience

Category	Biology	Physical Science	Total	Percent
1-5 years	1	1	2	14.3
6 - 10 years	1	3	4	28.6
11 – 15 years	1	0	1	7.1
16 – 20 years	2	0	2	14.3
21-25	1	2	3	21.4
26-30	1	1	2	14.3
Total	7	7	14	**100**

The data in Table 5 indicate that the majority of the participants, 4 (28.6%) of the Biology and Physical Science teachers had between 6 to 10 years of teaching experience. Three (21.4%) of the Biology and Physical Science teachers had 21 to 25

years of teaching experience. One Biology teacher had 11 to 15 years teaching experience.

4.2.3 Teachers' teaching qualifications

The teachers' teaching qualifications is presented in Table 6.

Table 6: Teachers qualifications

Qualification	Biology	Physical Science	Total	%
Basic Education Teacher Diploma	0	1	1	7.1
Bachelor of Education (B.ED)	6	3	9	64.3
Diploma in Chemistry (DC)	0	1	1	7.1
Higher Education Diploma (HED)	1	1	2	14.3
Master of Science (Physics)	0	1	1	7.1
Total	**7**	**7**	**14**	**100**

The data in Table 6 indicate that 9 (64.3%) of Biology and Physical Science teachers had the Bachelor of Education degree. Two (14.3%) of the Biology and Physical Science teachers had a Higher Education Diploma (HED). One Physical Science teacher had a Basic Education Teacher Diploma (BETD). One Physical Science teacher had an Advanced Diploma in Chemistry (ADC). The other Physical Science teacher had a Master of Science in Physics.

4.3 Theme one: The teaching of Biology and Physical Science practical work in senior secondary schools in the Zambezi region vis-a-vis the learning objectives outlined in the subjects' curricula.

Under this theme, the researcher looked at whether the practical work taught in Biology and Physical Science classes in the Zambezi Region follow the learning objectives outlined in the subjects' syllabi. The research findings about the teaching of Biology and Physical Science practical work were presented in the following

order: Findings from the questionnaires, findings from observations, findings from interviews and then findings from document analysis.

4.3.1 Results from the questionnaires

4.3.1.1 The use of practical work in teaching Biology and Physical Science

The number of teachers who used practical work in teaching Biology and Physical Science are shown in Figure 1.

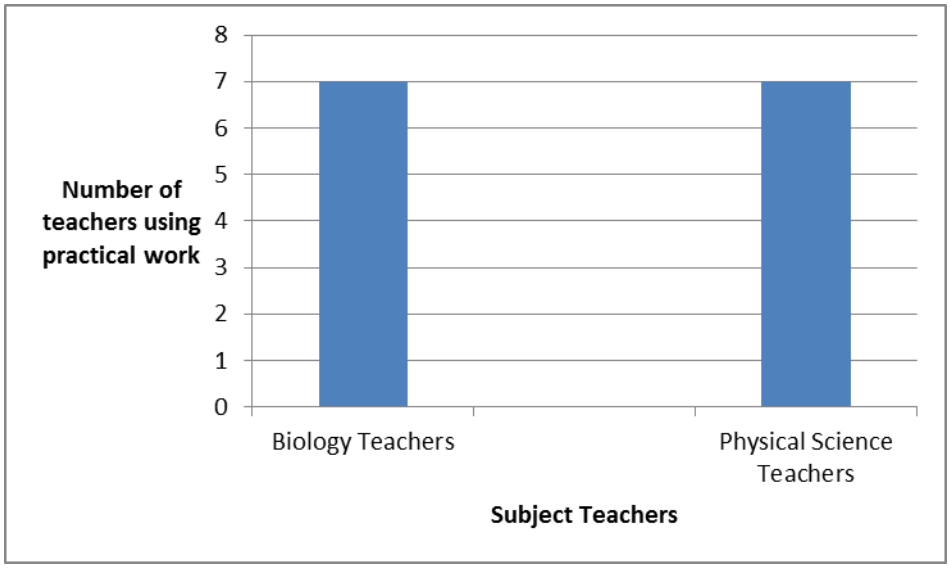

Figure 1: The use of practical work in teaching Biology and Physical Science

The data from Figure 1 shows that 7 Biology teachers and 7 Physical Science teachers used practical lessons in their teaching of Biology and Physical Science.

The Ministry of Education (2009, 2008) expects Biology and Physical Science teachers to teach practical work that are prescribed in the syllabi for senior secondary schools. Thus, it has become their (teachers) line of duty to teach practical work in order to equip learners with the competencies needed to pass their examinations and to handle related everyday issues.

4.3.1.2 Frequency of teaching practical work in Biology and Physical Science

The teachers were also asked to state how often they taught practical work in Biology and Physical Science. Table 7 presents the teachers' responses on how often they taught practical work in Biology and Physical Science at their schools.

Table 7: Frequency of teaching practical work in Biology and Physical Science

Frequency of teaching practical work	Biology	Physical Science	Total	%
Once a week	3	4	7	50
Once every lesson	0	0	0	0
Once in two lessons	0	0	0	0
Rarely	3	2	5	35.7
Never	0	0	0	0
Other, (depending on topic)	1	1	2	14.3
Total	**7**	**7**	**14**	**100**

Table 7 shows that 7 (50%) of the teachers taught practical work once in a week. five of the teachers rarely taught practical work. Two of the Biology and Physical Science teachers indicated that they taught practical work depending on the topics and basic competencies which required practicals.

4.3.1.3 Teaching time allocated to Biology and Physical Science practical work

Teachers were further asked to state the teaching time allocated to practical lessons in their schools. Table 8 shows the teachers' responses on the teaching time allocated to practical work lessons in Biology and Physical Science.

Table 8: Teaching time allocated to Biology and Physical Science practical work

Duration of practical lesson	Biology	Physical Science	Total
40 minutes	0	2	2
80 minutes	5	4	9
Other (in afternoon for 2 hours)	2	1	3
Total	**7**	**7**	**14**

The data in Table 8 reveal that practical lessons were not allocated the same duration in Biology and Physical Science in all the senior secondary schools involved in the study. Two teachers indicated that practical lessons were allocated 40 minutes. Nine teachers indicated that practical lessons were allocated 80 minutes, while three teachers indicated that if the practical work were longer than a double period, they were taught in the afternoons for two hours.

In Namibian, the time table for senior secondary schools had single lessons and double lessons throughout the whole week. According to the Natural Sciences Subject policy Guide (Ministry of Education, 2008a, p.3), "It is stated clearly in the curriculum for formal education that different ways of organizing teaching and learning will need flexible time-table, using different periods. Since Biology and Physical Science are subjects that require practical work; consecutive periods (a double period) on the school time-table could provide enough time for practical activities". Single lessons were supposed to be for theoretical lessons.

4.3.1.4 The use of classroom or laboratory when teaching practical work

Teachers were further asked to state whether they used a classroom or a laboratory when they taught practical work in Biology and Physical Science. Their responses are presented in Table 9.

Table 9: Places where practical work was taught in the senior secondary schools

Place	Biology	Physical Science	Total
Classroom	0	0	0
Laboratory	7	7	14
Total	**7**	**7**	**14**

The data in Table 9 indicate that all the 14 teachers used laboratories when they taught practical work. This suggests the schools have designed laboratories for practical work.

4.3.1.5 The aims of teaching practical work to learners

The teachers were supplied with the various aims of teaching practical work in Biology and Physical Science and asked to rank those aims in order of importance from 1 to 10 as follows: 1= the least important aim and 10 = the most important aim. The aims were coded and the total frequency counts of aims for every teacher were calculated. The rankings of the of teaching Biology and Physical Science practicals are presented in Figure 1 and Figure 2 respectively.

The ranking of the aims of teaching Biology practical work in schools are shown Figure 1.

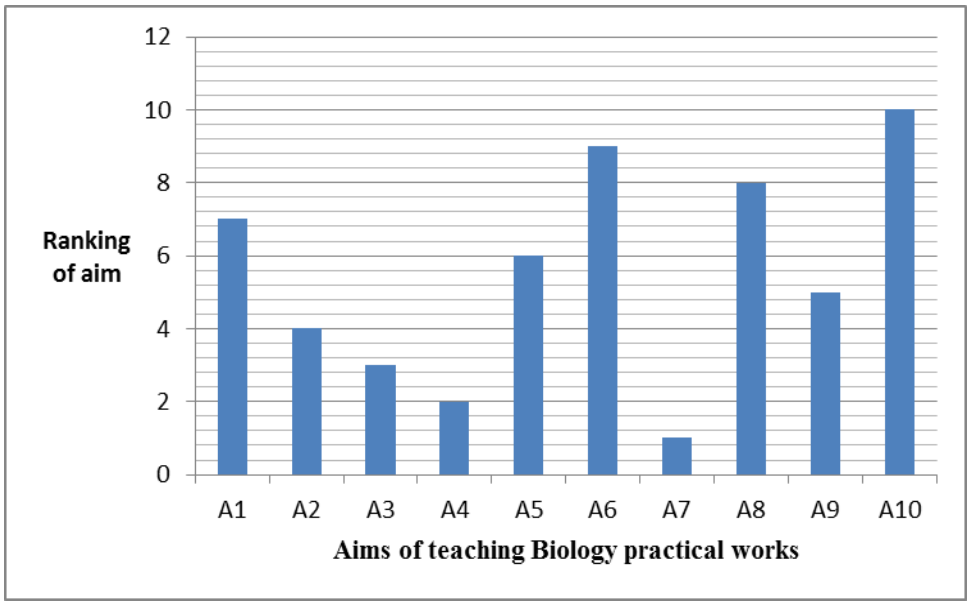

Figure 1: Aims of teaching Biology practical work

Note: **A1**-To enhance conceptual understanding; **A2**-To enhance investigative skills; **A3**-To enhance procedural knowledge about experiments; **A4**-To motivate, stimulate and maintain interest in science; **A5**-To develop certain scientific attitudes and manipulative skills; **A6**-To enhance the learning of scientific knowledge; **A7**-To encourage accurate observations and descriptions of objects; **A8**-To promote a logical scientific method of solving problems; **A9**-To verify facts and principles taught in theoretical lessons; **A10**-To make science phenomena real through actual experiment

Figure 1 show that aim A10 (to make science phenomena real through actual experiments) was ranked the most important aim of teaching practical work by the Biology teachers. The aim A6 (to enhance the learning of scientific knowledge) was ranked second by the Biology teachers. The aim A7 was the least ranked aim of teaching practical work by the Biology teachers.

The ranking of the aims of teaching Physical Science practical work in schools are shown Figure 2.

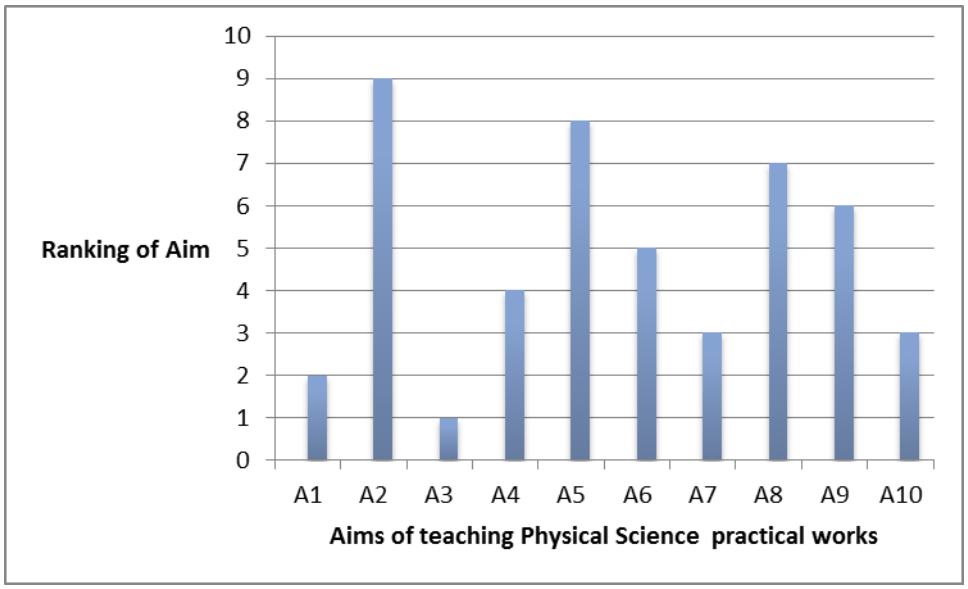

Figure 2: Aims of teaching Physical Science practical work

Note: **A1**-To enhance conceptual understanding; **A2**-To enhance investigative skills; **A3**-To enhance procedural knowledge about experiments; **A4**-To motivate, stimulate and maintain interest in science; **A5**-To develop certain scientific attitudes and manipulative skills; **A6**-To enhance the learning of scientific knowledge; **A7**-To encourage accurate observations and descriptions of objects; **A8**-To promote a logical scientific method of solving problems; **A9**-To verify facts and principles taught in theoretical lessons; **A10**-To make science phenomena real through actual experiment

Figure 1 show that aim A2 (to enhance investigative skills) was ranked the most important aim of teaching practical work by the Physical science teachers. The aim A5 (to develop certain scientific attitudes and manipulative skills) was ranked second by the Physical Science teachers. The aim A3 was ranked the least important aim of teaching practical work by the Physical Science teachers.

The data from Figure 1 and Figure 2 show that the aims of teaching practical work between biology and Physical Science teachers differ greatly. Aim A10 (to make science phenomena real through actual experiment) was ranked higher by Biology teachers while the Physical Science teachers ranked aim A3 (to enhance procedural knowledge about experiments) the highest. This difference is evident throughout the whole data sets.

4.3.1.6 Availability of teaching materials and equipment

Teachers were asked to state whether they have adequate materials to teach Biology and Physical Science practical work. Table 10 shows their responses.

Table 10: Resources for teaching practical work in senior secondary schools

Availability of resources	Biology	Physical Science	Total	Percentage
Yes	1	2	3	21.43
No	6	5	11	78.57
Total	**7**	**7**	14	100

Data in Table 10 reveal that 78.57% of the participants (teachers) indicated that their schools did not have adequate materials and equipments for teaching practical work in Biology and Physical Science. Only 21.43% of them indicated that they had enough materials and equipments. The results suggest that most senior secondary schools in the study did not have sufficient materials and equipments for teaching practical work, and this could compromise the practical work carried out as far as the syllabi guideline is concerned.

4.3.1.7 Type of practical work taught to learners in senior secondary schools

The questionnaire further asked the Biology and Physical Science teachers about the type of practical work they taught their learners in order to develop their (learners) practical skills. The responses obtained are presented in Table 11.

Table 11: Type of practical work taught to learners in senior secondary schools

Type of Practical	Biology	Physical Science	Total	Percentage
Investigations	2	4	6	18.0
Experiments	7	5	12	35.3

Fieldwork	2	0	2	5.8
Problem solving activities	1	0	1	2.9
Projects	1	1	2	5.8
Exercises	1	0	1	2.9
Excursion	0	0	0	0
Observations	5	5	10	29.4
Total			**34**	**100**

The data in Table 11 reveal that experiments (35.3%) were the most type of practical work taught to the senior secondary learners by the Biology and Physical Science teachers. Observations were the second type of practical work taught to the learners. While none of the teachers indicated to have used excursions as a type of practical work, problem solving activities and exercises were the least type of practical work taught to the learners.

4.3.1.8 Teachers ' perceptions of the teaching of practical work in Biology and Physical Science

Teachers were asked to rate on a five point scale their perceptions about teaching practical work in Biology and Physical Science. The teachers were asked to choose from: *All the time, Most of the time, Some time, Not often* or *Never* from the listed statements. For easy presentation of analysed data each statement was coded (see Appendix 14).

Figure 3 and Figure 4 below shows the percentage counts of the Biology and Physical Science teachers' perceptions of the teaching of practical work respectively.

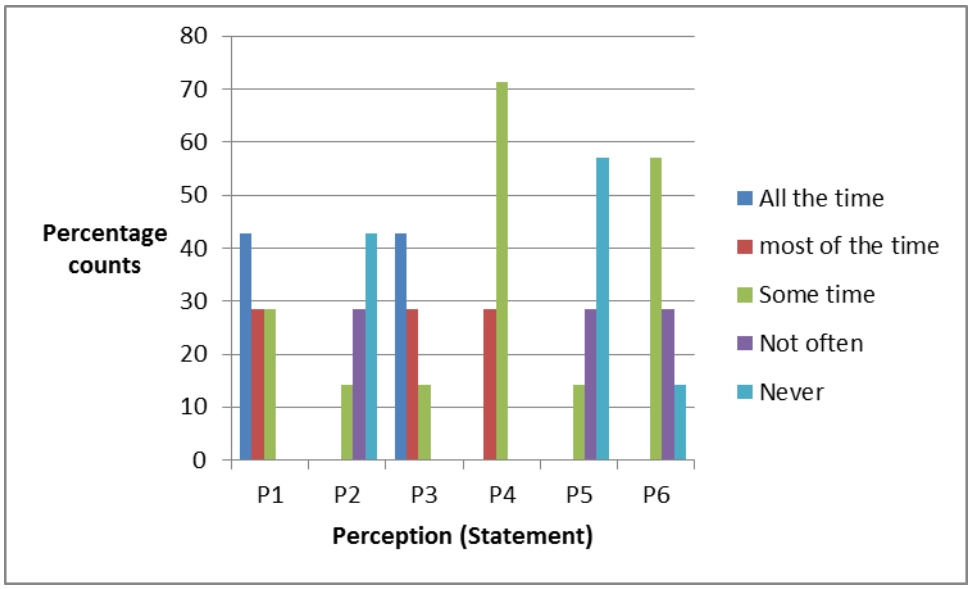

Figure 3: Percentage counts of the Biology teachers' perception of teaching practical work

Note: **P1=**Learners must carefully follow the teacher's instructions for experiments to reach the correct conclusions; **P2**=Learners plan their own experiments to investigate their own questions; **P3**-Whole-class discussion occurs when concluding the activities and summarising the main ideas; **P4**-Practical work is used to illustrate the concepts that have been introduced; **P5**=Practical work is carried out by learners before the theory is introduced; **P6**=Learners do hands-on practical work every week

Data from Figure 3 show that the Biology teachers who participated in this study believed that some time, the teaching of practical work is used to illustrate the concepts that have been introduced (72%) and Learners do hands-on practical work every week (56%).

From the teachers' responses, it was clear that most of the Biology teachers believed the teaching of practical work was about learners carefully following the teacher's instructions for the experiments to reach the correct conclusions and whole-class discussion when concluding the activities and summarising the main ideas.

Figure 4 below show the percentage counts of the Physical Science teachers

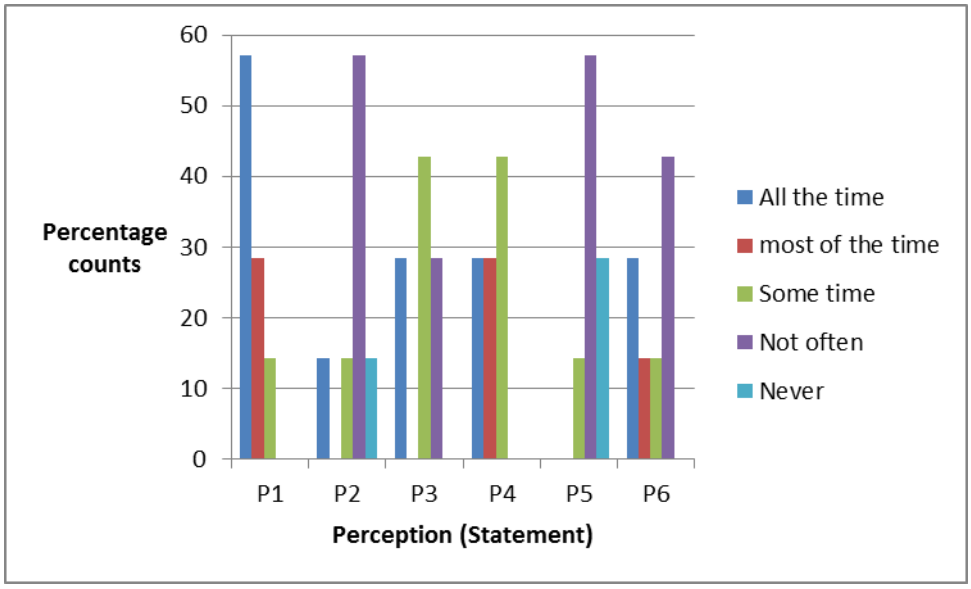

Figure 4: Percentage counts of the Physical Science teachers' perception of teaching practical work

Note: **P1**=Learners must carefully follow the teacher's instructions for experiments to reach the correct conclusions; **P2**=Learners plan their own experiments to investigate their own questions; **P3**-Whole-class discussion occurs when concluding the activities and summarising the main ideas; **P4**-Practical work is used to illustrate the concepts that have been introduced; **P5**=Practical work is carried out by learners before the theory is introduced; **P6**=Learners do hands-on practical work every week

Data from Figure 4 show that the Physical Science teachers who participated in this study believed that all the time, the teaching of practical work is about learners carefully following the teacher's instructions to reach the correct conclusions in practical experiments (57.14%), learners planning their own experiments to investigate their own questions (14.3%), whole-class discussion when concluding the activities and summarising the main ideas (28.5%), practical work being used to illustrate concepts that have been introduced (28.5%) and learners doing hands-on practical work every week (28.5%).

From the teachers' responses, it was clear that most of the Physical Science teachers believed the time the teaching of practical work was about learners carefully

following the teacher's instructions for the experiments to reach the correct conclusions.

As indicated by Clackson & Wright (1992), Gott & Duggan (1995), and Leach (1999), a teacher's belief or perception of the teaching of practical work can impact directly on the way she/he teaches practical work. Teachers should therefore have a clear understanding of what teaching of practical work entails. Having a clear understanding about the teaching of practical work might help the teachers to plan teachable practical activities and practical skills.

4.3.1.9 Teaching methods used in the teaching of practical work

The teachers were asked to indicate the teaching methods they used in the teaching of Biology and Physical Science practical work. The questionnaire contains 5 possible teaching methods from which the teachers were expected choose their preference. Table 12 shows the results of the teachers' responses.

Table 12: Teaching methods used in teaching Biology and Physical Science Practical work

Teaching method	Biology	Physical Science	Total	Percentage
Lecture method	3	2	5	18.51
Demonstrations	5	4	9	33.33
Group work	2	0	2	7.40
Experiments	3	1	4	14.81
Investigations	3	4	7	25.92
TOTAL			**27**	**100**

Table 12 shows that the majority of the participants, 9 (33.33%) of the Biology and Physical Science teachers indicated that they used demonstration in their teaching.

Two (7.40%) of the Biology and Physical Science teachers indicated that they used group work and five (18.51%) of them indicated that they used the lecture method when teaching practical work. Furthermore, 7 (25.92%) of the teachers indicated that they used investigation methods to teach practical work.

4.3.2 Results from observation schedules

The results of the lesson observations indicated that some teachers did actually teach Biology and Physical Science practicals as they indicated in the questionnaires responses.

As noted earlier, the Namibian Senior Secondary Certificate for Ordinary Level Biology and Physical Science syllabi suggests different practical activities or demonstrations for almost all the topics which the learners should be taught in preparation for the Applied Practical Skills examination (Ministry of Education, 2009). This may have negative effects on both the Biology and Physical Science learners who were in their final year of secondary school and are sitting for practical examination of the Namibia Senior Secondary Certificate Ordinary level.

Classroom observations were conducted with the aim of supporting or contradicting the claim by Biology and Physical Science teachers to have taught practical work. The researcher observed the teachers teaching different topics from the Grade 11 and 12 Biology and Physical Science syllabi. The classroom sizes, the classroom arrangement and the availability of teaching and learning resources for Biology and Physical Science were also observed. The results from the Observation Schedules are presented and discussed in this section.

4.3.2.1 Places where practical work was taught in the senior secondary schools

The five teachers who were observed had laboratories for teaching Biology and Physical Science practicals at their schools. It was observed that two Biology teachers and one Physical Science teacher taught practical work in the common laboratory where all science teachers can access to carry out practical work, while the other one Biology teacher and two Physical Science teachers the normal classrooms for teaching practicals work.

4.3.2.2 Number of learners per class

The number of learners per class observed ranged from 27 to 53 learners. The Biology practical classes had 27-53 learners while Physical Science practical classes from 36 to 48 learners. The observed average number of learners per class in both subjects 41 learners.

4.3.2.3 Classroom / Laboratory arrangement

Out of the five classrooms that were observed, 3 had rows and columns sitting arrangements, while in 1 classroom, learners were sitting randomly (scattered). In one classroom learners were well organised in groups. Their class was clean and had enough space allowing learners to move freely. One laboratory was not well organised but had rich visual displays of Physical Science on its walls.

4.3.2.4 Availability of teaching and learning resources and equipments

It was observed that chairs and tables for learners in both Biology and Physical Science classrooms were sufficient. It was also observed that in one of the urban schools, Physical Science Ordinary Level textbooks were adequate for learners while Biology Ordinary Level textbooks were inadequate. The observation results further revealed that in 3 out of the 7 senior secondary schools, all learners had exercise books. Furthermore, it was observed that the schools' laboratories did not have

adequate equipment for both Biology and Physical Science practical work. It was also evident, in the classroom observations, that the Biology teachers, Physical Science teachers and their learners did not have laboratory manuals for practical work.

According to Crawford (2000), "increasing costs of equipments and consumables for laboratories have put science laboratories in schools in a pathetic condition". The high cost of scientific equipment and infrastructure facilities required for science laboratories have resulted in some educational institutions being hesitant to put practical work on their priority list (Crawford, 2000). This might also be the case in most of the schools laboratories observed in the study. Table 13 shows data about the availability of teaching materials and equipments.

Table 13: Availability of teaching materials and equipments

Materials and equipments	**Sufficient**	**Insufficient**
Tables	√	
Chairs	√	
Textbooks		√
Exercise books	√	
Laboratory facilities (e.g. equipments and apparatus)		√
Supply of chemical reagents		√
Laboratory safety wears (e.g. lab coat, First Aid Box)		√

Note: **Sufficient** = enough for all the learners**. Insufficient** = not enough for all the learners**.**

Five of the observed schools had poor laboratory facilities, inadequate supply of chemical reagents, poor amount of equipment for experiments and the quantity of textbooks for learners seen by the researcher was inadequate. It was observed that most of the laboratories used by the Biology and Physical Science teachers did not have enough apparatus and equipment as shown in the excerpt photo below (Figure 5).

Figure 5: Common laboratory used for practical work at School F

It was also observed that some of the laboratories have unlabelled and expired chemicals and thus could not be used to perform experiments. It is apparent from the observations that the lack of laboratory equipments, apparatus and chemicals made it difficult for some Biology and Physical Science teachers to teach practical work in the study area.

The observations also revealed that a laboratory in one urban school (School D) was well equipped with basic apparatus and chemicals to enable practical work in Biology and Physical Science to be taught. Figure 6, shows the excerpt photo from the laboratory.

Figure 6: Biology laboratory at School D

At the back of the classroom, one can observe equipments, apparatus and cupboards stocked with some basic chemicals as well as relevant posters.

A science laboratory is a place where there is a high chance of accidents to occur, because of the nature of chemicals, apparatus, equipments and materials that are handled and stored therein. Examples of such accidents include: heat burns, chemical burns, cuts from sharp items, inhalation of gases among others. The first aid box, therefore, becomes handy in the event of such an accident. There is obvious lack of first aid boxes in both Biology and Physical Science laboratories, and this may endanger the safety of teachers and learners. The observations revealed obvious shortage of laboratory facilities and equipment in the rural senior secondary schools.

4.3.2.5 Duration of practical work in Biology and Physical Science in the schools

Out of the five practical lessons observed, four (66.6%) lasted for 40 minutes while the remaining two (33.4%) lasted for 45 minutes. These observations seem to suggest that most of the practical lessons only lasted for one period instead of a double period. Grade 11 and 12 timetables have provisions for both single lesson and double lessons. The single lesson slots are intended for teaching theoretical lessons, while the double lesson slots are intended for practical lessons because practical lessons need more time (Ministry of Education, 2009). The observed Biology and Physical Science teachers did not make use of the double lessons to teach practical work; instead they made use of the single lessons. This may make it difficult for the teachers to allow all learners to be actively involved during the practical lessons.

4.3.2.6 Teaching methods used in teaching Biology and Physical Science practical work in the schools

Classroom observation data revealed that the teaching methods used by the Biology and Physical Science teachers in the practical lessons included lecture method, group work, experiments and demonstrations. As observed, Teacher T11 at school F provided a lecture. In addition to lectures, T1, T3 and T8 exposed their learners to group work while T14 exposed his learners to teacher demonstration. Lecture method is refered to as a traditional teaching method. However, research indicates that the practice of presenting content through lecture method does little to foster achievement of practical skills or affect constructive learning (Hierbert & Stigler, 2000). This way of teaching may be disadvantageous to the learners because it minimizes the manipulation of equipments and social interactions among the learners. Constructivist teaching requires learners to build on their prior knowledge at their own pace, followed by group work. Group work is the heart of social

constructivist teaching and learning. It is believed that if group work is integrated into collaborative learning, it may help learners improve their achievement of practical skills (Tekkaya, 2003).

4.3.3 Results from interviews

In order to obtain in-depth information on the teaching of Biology and Physical Science practicals in senior secondary schools, face to face follow up interviews were conducted at the end of the lesson observations. Both the Biology and Physical Science teachers' views were synthesized into themes which are presented in relation to the interview questions.

4.3.3.1 What are your views on the teaching of practical work in senior secondary schools?

Different views were expressed by both the Biology and Physical Science teachers in describing the teaching of practical work in their schools. Some of the teachers indicated that they sometimes taught practical work, while others indicated that the teaching of practical work was very much neglected, emphasizing that they didn't teach practical work in their school due to the challenges of overcrowded classrooms and lack of laboratory facilities that are needed to teach practical. This is evident in the following responses. Teacher T11 (Biology), when commenting on the teaching of practical work in his school, said:

> *I think the issue of teaching practical work in my school is something I intend to be doing. Unfortunately there is a lot of stumbling challenges that I encounter in my teaching. Among other challenges includes the unavailability of resources that need to be used. I can prepare the workheet, I can prepare the practical, worksheet that is supposed to be used, but unfortunately I will discover that I don't have the apparatus and chemicals that are supposed to*

be used. So in the process, it becomes a challenge. So, kindly I will not even say that I'm using some practicals. Maybe once in a while just to keep up at least something is being done. Otherwise, what I have resorted to do is the issue of using the theoretical practical and exercises where I will explain the procedures of the practical even if these practicals are not going to be conducted because there are no chemicals or the apparatus that needed to be used. I think that is my views about the teaching of practical in the current school situation now.

Teacher T12 (Physical Science) gave his view about the teaching of practical work in his school. He remarked that:

Currently I will say the practical part is very much neglected. In other words we are not putting much emphasis in them. We don't do them.

In contrast, Teacher T7 noted that the practical work were taught at his schools but not as they were supposed to be. Teacher T7's reason was related to the availability of science equipment and resources.

Teacher T7 (Biology):

Teaching of practical work at my school is done but it is not as effective as it is supposed to be.

During the interviews with teacher T1 (Biology) and Teacher T12 (Physical Science), they mentioned that:

Teacher T1 (Biology):

The teaching of practical work in my school is something that most of the teachers are not doing. Teachers are not doing any experiments with their learners and I think this is because we have too many learners in our classes. For example, I have three classes for grade 12 and each class has 47

learners. All together, they go to one hundred and forty something. So how do I prepare practicals in a laboratory that takes only 20 learners? This means I have to do each practical topic five times or more in order to make sure that each group does practical. In reality, that is impossible. The practicals that we often do are those which require less apparatus and chemicals. And in most cases, these are done on the basis of demonstration. So, we do some practicals and the rest of the expected practicals are left out. So, the situation in my school is tough and our learners suffer a lot.

Teacher T2 (Physical Science):

Sometime we do investigations, sometimes we don't.

According to Kapenda (2008), lack of chemicals, equipments and apparatus are among the factors that create difficulties in teaching practical work. Moreover, Kandjeo-Marenga (2011) notes that a problem of overcrowded classrooms is alleged to be one of the fundamental issues that lead to poor implementation of practical work. Thus, the Biology and Physical Science teachers require teaching resources and manageable class size to teach practical work.

4.3.3.2 How would you describe the teaching of practical work in your school at the moment?

The Biology and Physical Science teachers described the teaching of practical work in their schools as challenging, demanding and requiring a lot of time to prepare. The main challenges identified were: unavailability of laboratory resources and large number of learners (overcrowded classrooms). The following were some of the teachers' interview responses about the teaching of practical work in their schools.

Teacher T11 (Biology):

Like I mentioned, currently the teaching of practical work is not going well because of the challenges that are there [unavailability of teaching resources]. Having these challenges it is unfortunate that we do not do those practicals.

Teacher T 12 (Physical Science), when commenting on the teaching of practical work, said:

As I said earlier, currently the practical part are very much neglected and we don't teach them.

Teacher T7 (Biology) mentioned that one factor affecting the teaching of practical work could be the large number of learners in the classrooms and he said:

I think I would rate it as moderate, if not below average due to the teaching levels. We have got Higher Levels learners and we have got Ordinary Level learners. At higher level, at least a bit of practical work is done to learners. But the problem is on the Ordinary level because they are the majority and the materials are not enough. So that is where the problem is. With higher level, the situation is a bit better because they are few.

During the interviews, Teacher T13 (Biology) highlighted that:

If most of the practicals are left out and not done with the learners it summarizes that they are not taught in the school.

Teacher T1 (Biology) remarked:

Not really good. I struggle, move up and down preparing and also looking for equipments to be used in practical investigations.

Teacher T2 (Physical Science) concluded that:

The teaching of practical work at present in my school depends on the availability of chemicals. In most cases, some chemicals or apparatus are

usually inadequate because Ordinary level is not considered as much as Higher level learners who are well cared for.

These results support what the teachers indicated in the questionnaires. In all cases, the teachers indicated that the classrooms were overcrowded and there were shortage of apparatus, equipments and chemicals. These findings suggest that the secondary schools which participated in this study had overcrowded classrooms which constrained the teaching of Biology and Physical Science practical work. Therefore, it is likely to be difficult for the teachers to employ practical work in their teaching processes.

4.3.3.3 Do you teach practical work to your learners?

The Biology and Physical Science teachers were asked to state if they taught practical work to their learners. The excerpts below illustrate the teachers' responses:

Teacher 12 (Physical Science)

Sometimes, but the teaching of practical work is affected by a number of factors.

Teacher 7 (Biology):

Yes, I do. As I said, especially with the Higher level learners.

Teacher T13 (Biology)

Yes I do teach practicals to my learner but that depends on equipments available. Time for preparing the laboratory is also a factor, because sometimes I am tired and I cannot prepare the laboratory in the afternoon. The big number of learners is the big issue when it comes to teaching the practicals.

Teacher T1 (Biology):

Yes.

Teacher T2 (Physical Science)

Yes. I do.

The teachers' responses obtained in the interviews contradicted the responses given in the questionnaires. In the questionnaires, all the teachers indicated that they taught practical work in Biology and Physical Science.

4.3.3.4 How do you teach practical work to your leaners?

The participants remarked that in the absence of chemicals or apparatus, they taught practical work in form of theory, using worksheets, demonstrations and practical videos.

Teacher T11 (Biology):

I have resorted to using the theoretical practical exercise where I explain the procedures of the practical even if these practical work are not going to be conducted because there are no chemicals or the apparatus that need to be used. When I have practicals to test for osmosis in the potato tubers and don't need so much complicated things, what I usually do is prepare the worksheet which contains instructions that learners need to follow and give then. I provide them with the apparatus that they need and from there the learners carry out the experiment. That is what I usually do and at the end, the learners will be able to respond to the questions that are on the worksheet.

Teacher 12 (Physical Science):

With the few apparatus and chemicals that I have, what I normally do is demonstrations. I have my own station and I invite learners to come there. While I explain to them what we are doing, they will be observing . That's how I do it.

Teacher T7 (Biology):

There are many ways in which the practical work is taught. There are times when the teacher will demonstrate the experiment first and afterward allow learners to also do the experiment, following what was demonstrated by teachers. Another way is when you prepare worksheets with instructions and there then teacher will serve as a facilitator, checking whether learners are following the instructions on the worksheet. So, it is not a one way thing. It depends on what the learners must do for you assess.

Teacher T13 (Biology):

In most practicals, I prepare the practical sheets that learners need to follow the procedure and steps for that practical. At the end of the practical sheet there are discussion questions based on what my learners have done. Sometimes, I photocopy practicals from textbooks and use them with my learners. Due to lack of resources I have resorted to using practical videos downloaded from the internet YouTube. It saves time and it relieves stress. But these videos are just demonstrating to the learners while they are doing nothing.

Teacher T1 (Biology) remarked:

Sometimes I do it theoretically because of lack of materials to be used in the practical investigations.

Teacher T2 (Physical Science) remarked:

I always make some worksheets that guide learners on what is required to keep them in the frame of the prepared practical work.

From the above, it seems that worksheets, demonstrations, theoretical practicals and practical videos are frequently used by Biology and Physical Science teachers to teach practical work in the schools.

4.3.3.5 Does your teaching of practical work follow the learning objectives outlined in the subject's curricula?

Responding to the questions, the Biology and Physical Science teachers stated how their teaching of practical work followed the learning objectives outlined in the subjects' curricula.

Teacher T11 (Biology) said:

> *Yes, because what I always do is that I go into my syllabus to check the basic competencies. Actually, when you see our Biology syllabus, there are suggested practical activities. So, I will definitely use those learning objectives to scheme up my practicals that I will always conduct.*

Teacher 12 (Physical Science):

> *Yes, I check the syllabus before teaching experiments. I check for the skills and competencies that are prescribed.*

Teacher T7 (Biology):

> *Yes, very much, depending on the skills and competencies that learners should achieve. So, I really follow the syllabus, especially the competencies.*

Teacher T13 (Biology):

> *Yes, my teaching follows the objectives because what I teach to my learners are those suggested practicals which appear at the bottom of the syllabus at the end of each theme or topic. Some topics have more suggested practical topics. So, what I always do is to at least do one, two or three practicals among the suggested ones.*

From the interview excerpts, one can deduce that all the teachers followed the learning objectives outlined in the syllabi to teach practical work. In general, the teachers consulted their syllabuses to check the suggested practical objectives.

4.4 Theme two: Practical skills the Biology and Physical Science teachers want the learners to achieve from the practical work they teach in senior secondary schools.

The data in this section was gathered through the questionnaires, observations, interviews and document analyses. The findings from the questionnaires are presented first, followed by the findings of the observations, interviews and then the findings from the document analyses.

4.4.1 Results from the questionnaires

The questionnaires contain the following questions: what practical skills do you teach during practical work? What is your (teacher) role during practical work? What do your learners do during actual practical lessons and do your learners have a laboratory manual?

4.4.1.1 What practical skills do you teach your learners during practical work?

The Practical skills stated by the Biology and Physical Science teachers were coded (Appendix 15) and the total frequency counts and percentage occurrences of each practical skill were calculated.

The percentage occurrences for practical skills taught by Biology and Physical Science teachers are shown in Figure 7.

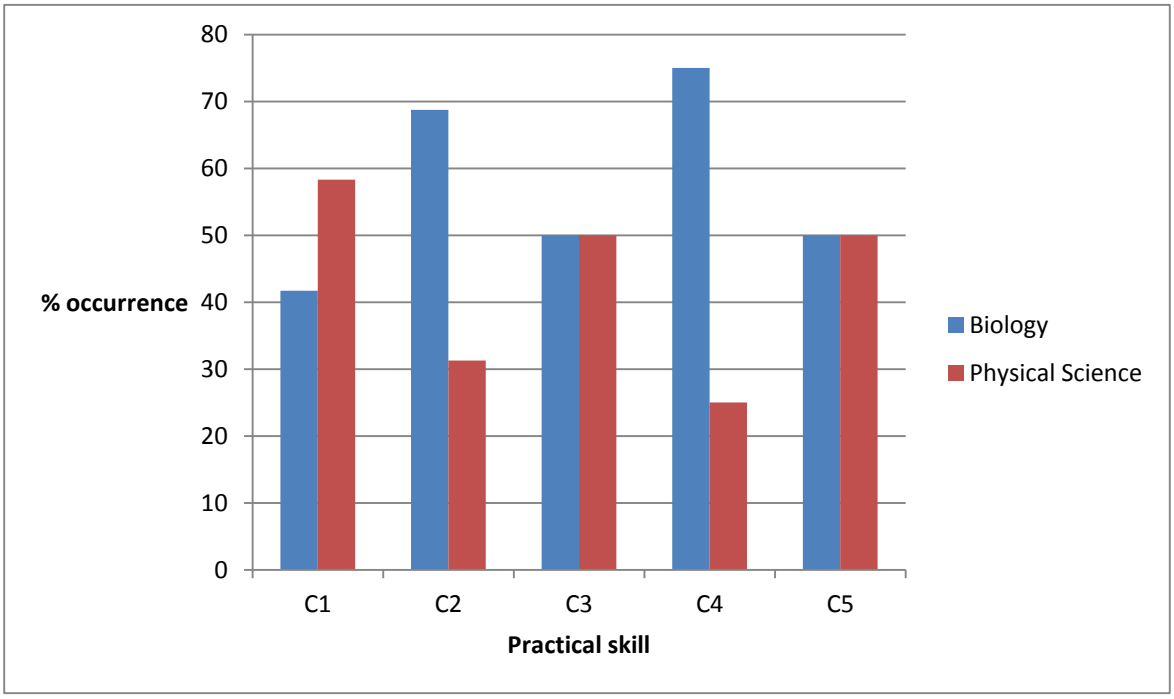

Figure 7: Practical skills taught by Biology and Physical Science teachers

Note: **C1**=follow a sequence of instructions; use appropriate techniques; handle apparatus/material competently and have due regard for safety; **C2**= make and record estimates, observations and measurements accurately; **C3**=handle and process experimental observations and data, including dealing with anomalous or inconsistent results; **C4**=apply scientific knowledge and understanding to make interpretations and to draw appropriate conclusions from practical observations and data; **C5**=plan, design and carry out investigations and suggest modifications in the light of experience.

Figure 7 shows that the most taught practical skills by Biology teachers were applying scientific knowledge and understanding to make interpretations and to draw appropriate conclusions from practical observations and data (75%) and making and recording estimates, observations and measurements accurately (68.75%). Also prominent was learners following a sequence of instructions; using appropriate techniques and handling apparatus/materials and planning, designing and carrying out investigations and suggesting modifications in the light of experience (50%). Practical skill C1 had a high percentage occurrence (58.3%) from Physical Science teachers while practical skill C4 had a high percentage occurrence (75%) from Biology teachers. However practical skills C3 and C5 had equal percentage

occurrence (50%) in both Biology and Physical Science teachers' preference of the practical skills taught.

4.4.1.2 Teachers' role during Biology and Physical Science practical work

The Natural Sciences Subject policy Guide (Ministry of Education, 2008a), states that Natural Sciences teacher as the classroom manager has the responsibility to facilitate teaching and learning both inside and outside the classroom in order for the learners to acquire the necessary knowledge and skills. Therefore, the practical skills acquired by the learners are greatly influenced by how they were taught. Table 14 shows the responses of the teachers on their roles during practical lessons in schools.

Table 14: Teachers' role during practical lesson

Category	Biology	Physical Science	Total	Percentage
Explaining steps/procedures	0	2	2	14.3
Demonstrating to class	2	3	5	35.7
Facilitating	3	0	3	21.3
Giving instructions	3	4	7	50.0
Teach the learners	1	1	2	14.3
Helping / assisting the leaners	1	1	2	14.3
Asking questions	1	0	1	7.14
Providing practical worksheet	2	1	3	21.4
Giving feedback	2	0	2	14.3
Guide and monitor learners	1	0	2	14.3
Evaluate / Assess	1	0	1	7.14

Data in Table 14 show that half (50%) of Biology and Physical Science teachers indicated that their role was giving instructions on the procedures to be followed by the learners. About 35% of the Biology and Physical Science teachers also indicated that during practical work they demonstrated how the experiment was done. In addition, the teachers indicated that during practical work, they facilitated practical work and gave worksheets of practical activities.

In the constructivist classroom, the teacher's role is to facilitate discussion. Thus, the teacher's main focus should be on guiding leaners by asking questions that will lead them to develop their own conclusions on the practical activity, encouraging learners to engage in dialogue, both with teacher and with one another; accept learners' autonomy and initiative; encouraging learner inquiry by posing open-ended questions and asking learners to ask each other and providing time for learners to construct relationships (Ogunmade, 2005).

4.4.1.3 What learners did during Biology and Physical Science practical work

The questionnaire asked teachers about the activities that learners did during practical lessons. Table 15 presents learners' activities during Biology and Physical Science practical lessons in the study area.

Table 15: What learners did during Biology and Physical Science practical work

Category	Biology	Physical Science	Total	Percentage
Follow instructions	4	1	5	35.7
Make observations	3	3	6	42.8
Record results	1	4	5	35.7
Analyze /draw conclusions	3	2	5	35.7

Handle / use apparatus	0	4	4	28.5
Carry out practical	2	4	6	42.8

From the data in Table 15, learners observe the teachers demonstrating and explaining (42.8%), follow instructions on worksheets (35.7%), record experimental results (35.7%), analyse and draw conclusions (35.7%), handle and use apparatus (28.5%) and carry out practical experiment (42.8%).

The findings here suggest that the teaching of practical works in the senior secondary schools is highly teacher-directed; the learners are passive observers, watching teachers' demonstrations and there are limited opportunities for learners to do hands-on activities.

4.4.1.4 Do learners have laboratory manuals?

Teachers' responses whether their learners had laboratory manuals for carrying out practical works in Biology and Physical Science are presented in Figure 7.

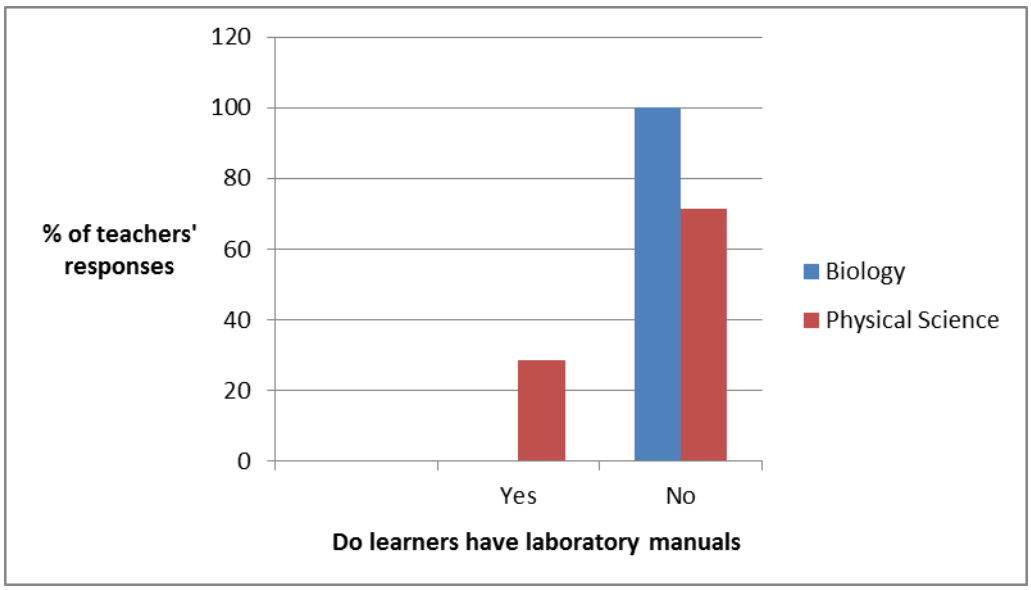

Figure 8: Do learners have laboratory manuals

From Figure 7, all the Biology teachers (100 %) and 70% of the Physical Science teachers indicated that their learners did not have laboratory manuals for carrying out practicals, while 30% of the Physical Science indicated that their learners had laboratory manuals for carrying out the practicals. These responses suggest that most leaners in the senior secondary schools did not have laboratory manuals for carrying out Biology and Physical Science practicals

All senior secondary schools offering Biology and Physical Science should have laboratory manuals for learners, because Biology and Physical Science are experimental subjects as stated in the Namibian Senior Secondary Certificate Ordinary Level Biology and Physical Science syllabi (Ministry of Education, 2009; Ministry of Education, 2008). The teaching of Biology and Physical Science cannot be done theoretically only; there should be a practical component. However, no laboratory manual was seen by the researcher during the lesson observations.

4.4.2 Results from the practical lessons observations

In this section, lesson observations were intended to identify teachers' role during practical work.

4.4.2.1. Teachers' role during teaching of practical works

In the practical lessons observed, the teachers performed several activities. Table 16 shows the activities that the teachers performed during the practical lessons.

Table 16: Activities performed by the teachers during practical lessons

Activities performed by the teachers	Frequency
Teacher moves around asking learners to prepare salt solution	2
Teacher carries out demonstration on how to weigh and reset the scale	1

Teacher provides assistance with the resetting of stop watch	1
Teacher read instructions and explain procedures	3
Teacher ask questions from observations	1
Teacher ask learners to complete table and draw graphs	1
Teacher explains how to test a leaf for starch using PowerPoint	1

Table 16 shows that in two practical lessons, the teachers moved around asking the learners to prepare salt solutions during experiments. Three teachers read the instructions and explained the procedures while the class was listening. One teacher provided assistance to the learners with the resetting of the stop watch and demonstrated how to weigh with the scale. In the other practical lessons, the teachers asked the leaners to complete tables and draw graphs. Another teacher explained how to test a leaf for starch using the PowerPoint presentation.

4.4.2.2 Practical skills teachers taught their learners

The Biology and Physical Science syllabi show the intended practical skills (Ministry of Education, 2008, 2009), which the science teachers should teach the learners. Table 19 shows the prescribed, observed and not observed practical skills teachers taught to their learners.

Table 17: Prescribed, observed and not observed practical skills

Skills	Prescribed practical skills	Observed (√) or not observed (X)
Skill C1	a) Follow sequence of instructions b) Use appropriate techniques c) Handle apparatus and material competently; d) Have regard for safety	a) √ b) X c) √ d) X
Skill C2	e) Make and record estimates; f) Make and record observations; g) Make and record measurements accurately	e) X f) √

		g) √
Skill C3	h) Handle and Process experimental observations i) Handle and Process experimental data j) Deal with anomalous or inconsistent results	h) X i) √ j) X
Skill C4	k) Apply scientific knowledge and understanding to make interpretation from practical observations and data l) Apply scientific knowledge and understanding to draw appropriate conclusions from practical observations and data	k) X l) X
Skill C5	m) Plan investigations, n) Design investigations, and o) Carry out investigations p) Suggest modifications in the light of experiences	m) X n) X o) √ p) X

Table 17 shows that not all the prescribed practical skills were observed in the practical skills the teachers taught the learners. The teachers did not teach all the practical skills except the following practical skills: Skill C1 follow sequence of instructions; handle apparatus and material competently; skill C2 make and record observations; as well as make and record measurements accurately; skill C3 handle and process experimental data and skill C5 carry out investigations. The practical activities given to the learners did not provide opportunity for them to acquire the practical skills in skill C4.

4.4.3 Results from interviews

Another aspect that the teachers were asked was the practical skills they aimed to achieve from practical work they taught their learners. The respondents mentioned that they wanted their learners to know how to follow instructions or procedures, handle the instruments, make observations, record, design experiments, carry out investigations, do projects, make drawings, calculate, measure, communicate, solve problems and think critically. The following are the practical skills the teachers wanted their learners achieve from the practical works they taught their learners.

Teacher T11 (Biology):

Usually those will be following instructions. I want to see if, when given any instructions, procedures or methods as outlined, the learners can follow them as outlined. Whether they can read the instructions and then apply them.

Teacher 12 (Physical Science):

We teach them to know the instruments and how these instruments work. The learners should know how handle instruments. And they should be able to improve on their observations skills, and record all things that we are looking at when we are conducting experiments and practicals.

Teacher T7 (Biology):

There are times when some learners will be able to design and carry out experiments, undertake investigations; do projects where they investigate nitrogen deficiencies in crops. They may also make a questionnaire that they can use to find out tooth decay, the extent of tooth decay.

Teacher T13 (Biology):

I expect them to follow the instructions and procedures. I also teach them to be patient, because in science laboratory if they rush they can cause serious accidents. Some apparatus are expensive. So if they break them these days the school complains about not having money. They also make drawings in some practical. They also calculate, measure temperatures and observe.

Teacher T1 (Biology):

One should have knowledge on how to experiment and handle some equipment.

Teacher T2 (Physical Science):

Communication, problem solving, critical and creative thinking skills.

The practical skills from the excerpts above were reflective of what the Biology and Physical Science teachers indicated in the questionnaires. The teachers stressed the need for the learners to know how to follow practical instructions, handle the instruments and how they should be used to avoid accidents during practical work. Teacher T1 said skills such as knowing how to use apparatus and materials are important in developing higher-order thinking skills needed to conduct experiments that warrant the application of more complex practical skills.

4.5 Theme three: Assessment criteria used by the Biology and Physical Science teachers to assess the practical skills acquired by the learners.

This section presents and discusses the teachers' views on assessment criteria used to assess the practical skills acquired by the leaners. The findings were obtained through the use of questionnaires, interviews and document analyses.

4.5.1 Results from the questionnaire

4.5.1.1 How do Biology and Physical Science teachers assess their learners at the end of the practical lesson

Learners are supposed to be assessed at the end of the practical lessons in order to determine whether they (learners) have achieved the practicals skills. The Biology and Physical Science teachers were asked how they assessed their learners at the end of the practical lessons. Table 18 presents how the teachers assessed their learners at the end of the practical lessons.

Table 18: How teachers assessed learners at the end of a practical lesson

How do you assess your learners	Biology	Physical Science	Frequency	Percentage
Written practical tests	5	3	8	57.1
Post laboratory questions	2	6	8	57.1
Projects	1	2	3	21.4

Practical report	2	6	8	57.1

Data in Table 18 revealed that, the most common used types of assessment by the teachers were written practical tests, post laboratory questions and practical report (57.1%) while projects are the least used type of assessment (21.4%). However, from the lesson observations, it was found that the learners did not submit any work to the teachers for assessment after the practical lessons.

4.5.1.2 What assessment criteria do the Biology and Physical Science teachers use to assess the practical skills in secondary schools?

The questionnaire asked the teachers the assessment criteria they used to assess practical skills. Figure 9 presents assessment criteria used by Biology and Physical Science teachers to assess practical skills.

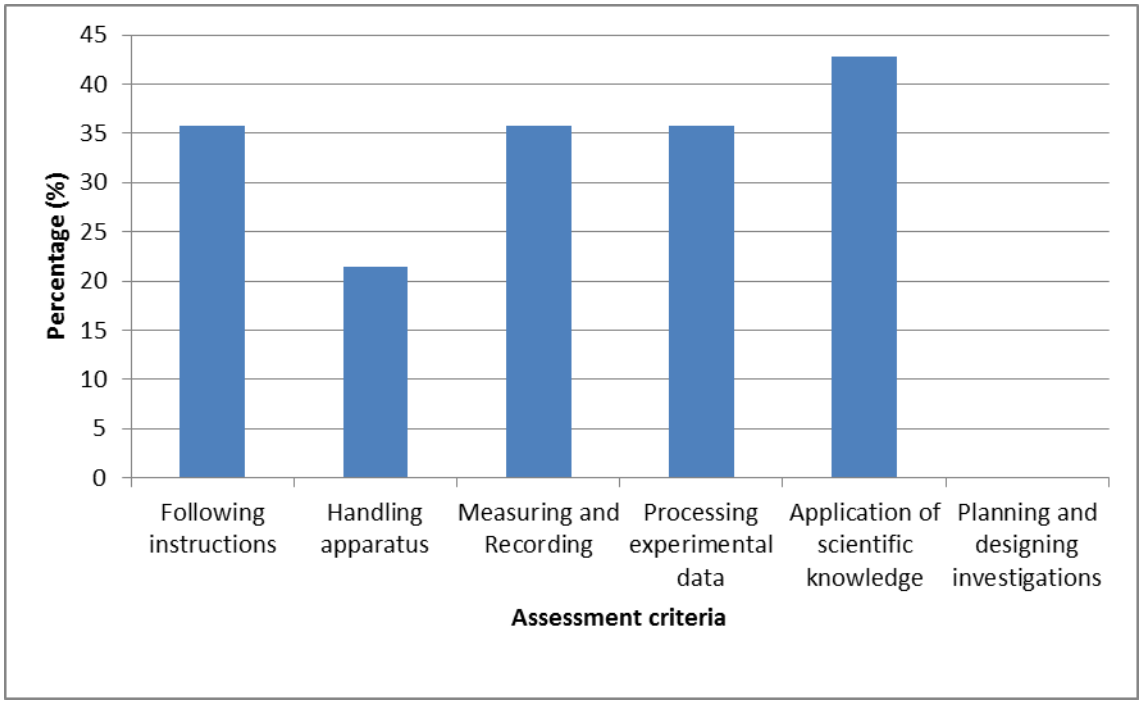

Figure 9: Assessment criteria use by the Biology and Physical Science teachers

Figure 9 shows that the assessment criteria used by the Biology and Physical Science teachers are the application of scientific knowledge (43%), following instructions

(36%), measuring and recording (36%), processing experimental data (36%) and handling apparatus (21%).

4.5.2 Results from interviews

From the interviews conducted, some of the teachers seemed not to understand what was meant by assessment criteria. This is indicated from the responses of Teacher T11, T12, T1 and T2. However, Teacher T7 highlighted the criteria with reference to the syllabus.

Teacher T11 (Biology) commented that:

> *In terms of the assessment, I give my learners a practical test at the end of the activity. They will be provided with worksheets to complete. I always give the practical test to find out if they can still remember what they have done.*

Teacher 12 (Physical Science):

> *It depends on the type of questions that I put in my assessment activities. For example, I may ask how they (learners) are going to obtain an insoluble salt from the solution. So, they will see that they have to write something on the filtration process and make drawings.*

Teacher T7 (Biology):

> *We have criteria like knowledge with understanding, handling of information, application and problem solving, discovery and all such type of things and practical experimental investigations skills. I use the criteria that are found at the back of the syllabus. So I use them to design an assessment criterion to mark my learners work according to the 1 to 6 grading points.*

Teacher T1 (Biology):

> *I design a grading exam to assess broad range content.*

Teacher T2 (Physical Science):

I use the prepared CASS [Continuous Assessment] forms for Grade 8-10 which demands projects, practicals test, and topic tasks. For senior level the criteria is organized as in Paper 3 written practical paper.

The Ministry of Education expects Biology and Physical Science teachers to assess the learners according to the criteria prescribed in the syllabi and award marks for each of the experimental skills in terms of the Performance Criteria Descriptors (i.e. a 6-point scale (Ministry of Education, 2009). Overall, the Biology and Physical Science teachers gave different views on the assessment criteria question. Some of the views showed that Teacher 11, 12, 1 and 2 were not aware of the assessment criteria specified in the syllabi, while Teacher 7 seemed to know the assessment criteria. The criteria presented in the NSSCO Biology and Physical Science syllabi provide a clear guideline on how assessment of practical skills should be done (Table 2).

4.5.3 Results from documents

Different documents had different contributions to make in the study. Different teachers covered different topics based on the syllabi topics and lesson objectives. The topics and practical work covered by the teachers are shown in Table 19 below.

Table 19: Topics and practical learning objectives covered by different teachers

Teacher	**T1**	**T3**	**T8**	**T11**	**T14**
Topic of practical lesson	The effect of exercise on heart beat and breathing rate	To investigate osmosis	Titration	Testing a leaf for starch	Thermal expansion of solids

Practical learning objective	*Investigate the effect of exercise on the rate of heart beat*	*Carry out experiments to investigate the effects of sucrose solutions of different concentrations; measuring; diffusion of substances through a partially permeable membrane (Visking tubing)*	*Investigate how concentrated the ethanoic acid in commercial household vinegar is*	*investigate the effects on starch production of absence of light, chlorophyll and carbon dioxide*	*Heat a sample of ice and record the temperature at constant intervals*

Table 20 presents the findings from the analysed documents.

Table 20: Findings from document analyses

Category	Comments	Source
Type of practical work		
Teaching method	Demonstration, experiment, investigation, teacher presentation, group work,	D5
Practical skills taught	Make measurements, record measurements, process experimental data, handle apparatus, make observations	D7, D8
Practical skills assessed	Handling apparatus, make and record measurement, process experimental data,	D7, D8
Assessment method	Oral questioning, worksheets, discussion questions, question written on the board,	D7, D5, D8
Assessment criteria	Mark scheme for discussion questions	D5

The researcher analysed the Namibian Senior Secondary Certificate Ordinary Level Biology and Physical Science syllabi (Ministry of Education, 2009, 2008) in order to find out whether there were practical work that had been suggested for the topics above. For all the topics covered by the Biology and Physical Science teachers, there

was more than one suggested practical work which the teachers were supposed to teach their learners. The Natural Sciences Subject policy Guide (Ministry of Education, 2008a), recommends learner-centred approach for teaching practical work. It suggests that through learner-centred teaching learners are actively involved.

The Natural Sciences Subject policy Guide states that the suggested practical activities required for each topic in the syllabus are considered basic and all learners should be exposed to them as a minimum requirement" (Ministry of Education, 2008a). Therefore, Biology and Physical Science teachers are required to teach practical work to their learners on every topic as prescribed in the syllabus. However, from scheme of work, teachers were not following what was prescribed in the syllabus because not all of them taught practical work on every topic.

Only teacher T3 in school B had a practical work lesson plan. However, the lesson plan was incomplete. For example the lesson plan did not indicate the practical learning objective, introduction, homework, consolidation and assessment. Teacher T3's lesson plan had no teaching and learning aids. Data from the lesson plan seemed to suggest that Teacher T3 did not follow learning objectives for suggested practical work as outlined in the syllabi because the objective in the lesson plan did not match with the suggested practical in the syllabi. The lesson plan indicated that teacher T3 planned for a theoretical lesson and not practical work. Teacher T3's lesson plan showed that he used group work as a method of teaching practical work. Teachers T3, T8, T11 and T14 seemed not to realise the need to plan practical lessons as they do not prepare practical lesson plans. In lessons where teachers did not have lesson plans and scheme of work, it was difficult for the researcher to follow the lessons.

In analysing the learners' workbooks it was clear that T1, T3 and T8 used worksheets as practical guides for learners. T14 used practical activities in the textbook. The learners' workbooks also indicated that assessment of practical skills was mainly in terms of post-practical work questions, written work, classwork and past examination questions. However, there was no evidence of assessment criteria for assessing the practical skills achieved by learners. In the absence of assessment criteria, the researcher established that the teachers were not able to connect practical work they taught to the practical skills they intended their learners to achieve. The practical work taught by the teachers were oriented towards activities that were concerned with learners answering questions and little in helping them to acquire the practical skills outlined in the syllabi.

4.6 Theme four: Teachers views about improving the teaching of Biology and Physical Science practical work in senior secondary schools in the Zambezi region?

This section presents and discusses the Biology and Physical Science teacher's suggestions about what could be done to improve the teaching of practical work in senior secondary schools.

4.6.1 Results from questionnaires

The questionnaire had three questions under Theme 4.

4.6.1.1 What problems do you experience when teaching practical work to your learners?

The information provided by the Biology and Physical Science teachers on the problems they experienced when teaching practical work is presented in Figure 10

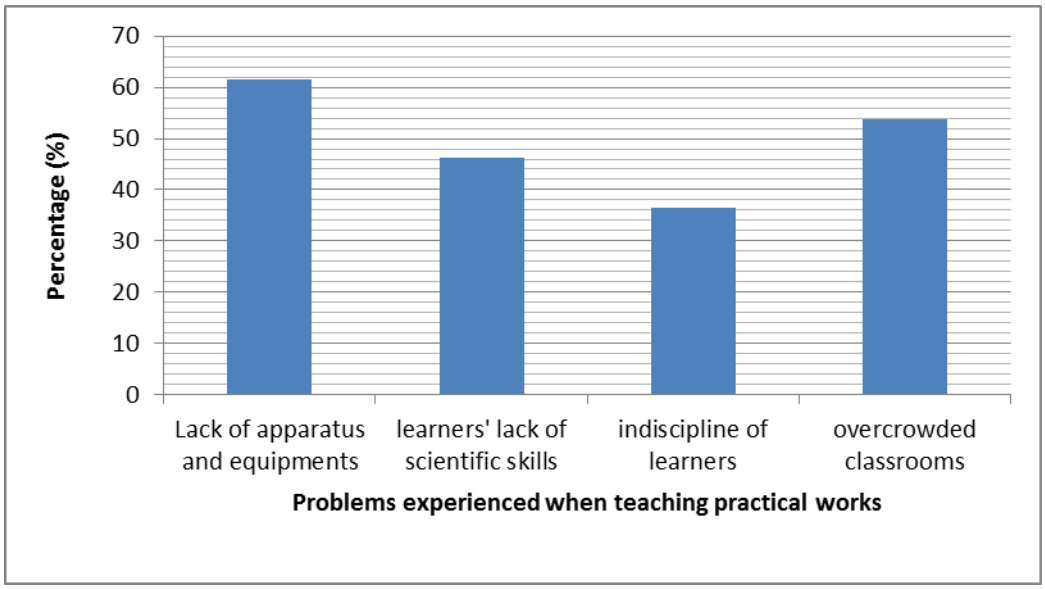

Figure 10: Problems experienced when teaching practical work

Figure 10 shows the lack of apparatus, chemicals and equipments (61%) as the most common problem experienced by the Biology and Physical Science teachers when teaching practical work in senior secondary schools in the Zambezi Region. Lack of resources is a key constraint to the teaching of practical work in the study area. The other important problem constraining the teaching of practical work in Biology and Physical Science is laboratory space and overcrowded classrooms (53%). Teacher T6, T7, T8, T910 and Teacher T13 indicated that the laboratory space was small for all their learners to carry out practicals (Appendix 18). Teacher T2, T5, T6, T7, T11 and T12 indicated that the other problems that they experience lied with the learners. These include leaners' failure to interprete experimental results, learners not exposed to practical work from lower grades, lack of scientific skills, lack of communication and observation skills and fear of experimenting (46%). Lastly, lack of interest in practical activities and discipline (36%) were also indicated by the teachers as problems affect the teaching of practical work.

4.6.1.2 How do the problems affect the teaching of practical work in Biology and Physical Science?

The crucial challenges encountered by Biology and Physical Science teachers in the teaching of practical work were lack of apparatus, chemicals and equipments. According to the Biology and Physical Science teacher, these challenges affected the teaching of practical work (Appendix 19).

Teachers T1, T10, T11 and T13 indicated that it was difficult to teach practical work at their schools due to shortage of materials and overcrowded classes. Teacher T13 also indicated that the teaching of practicals was affected by the fact that the laboratories were too small for the learners at any given practical session. This was supported by Teacher T5 who indicated that more time was needed to repeat an experiment with different groups of learners due to limited space in the laboratory. Additionally, Teacher T5 indicated that learners needed to wait for their turn for practical experiment. Teachers T12 observed that the problems of not teaching practical work denied learners the opportunity to engage in practical activities and apply critical thinking, logical and scientific reasoning. Teacher T4 indicated that there is a higher failure rate in Physical Science because learners took examinations without practical skills. The teachers' concerns about the lack of chemicals, materials, apparatus, space and time to prepare and teach practical work is a serious concern in the study area.

Ramorogo (1998), reported that the teaching of practical work has the potential of engaging learners in active construction of knowledge were teaching resources are available and utilised. Ramorogo (1998) also reported that large classes, shortage of apparatus, equipments and the lack of laboratories could be serious impediments to

teachers in involving learners in meaningful practical activities. He further remarked that such practices denied learners the opportunity to create knowledge in the course of social interactions.

4.6.1.3 What do you think should be done to improve the teaching of practical work in Biology and Physical Science?

The aim of this question was to survey the views of the Biology and Physical Science teachers on what they thought could be done in order to improve the teaching of practicals work in senior secondary schools in the Zambezi Region. The responses of the teachers are presented in Figure 11

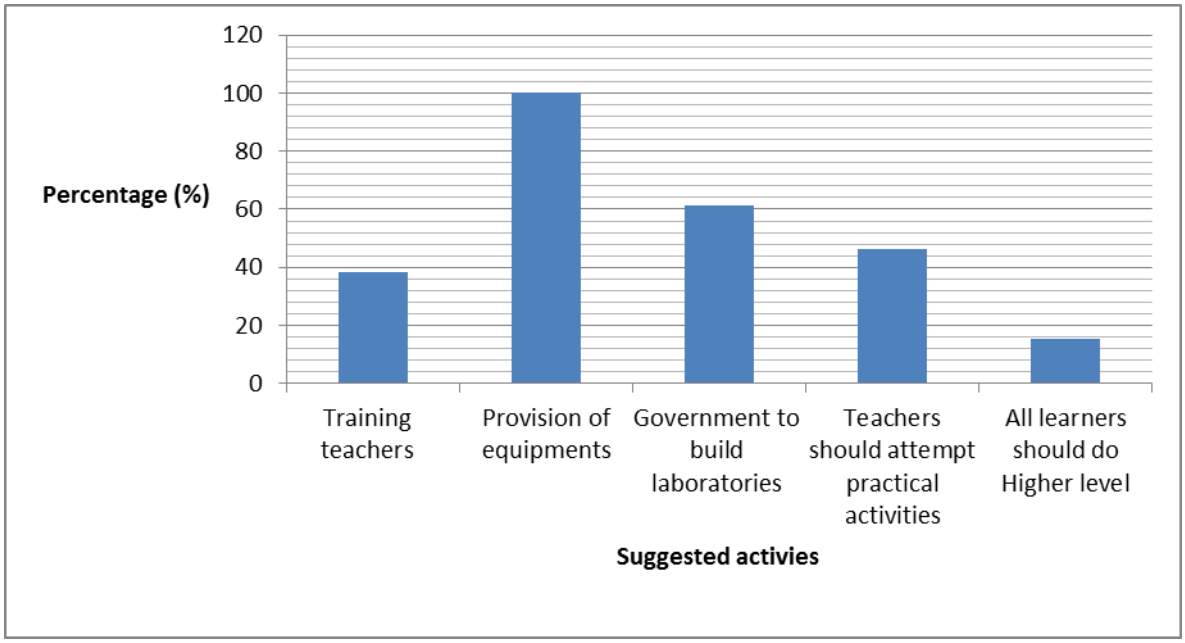

Figure 11: Suggestions for improving the teaching of practical work

Data in Figure 11 reveal that the most common suggestions by Biology and Physical Science teachers for improving the teaching of practical work in senior secondary schools in the study area include: provision of equipments (100%), government to build laboratories and expand the classrooms (61%), the teachers should attempt to teach the suggested practical activities in the syllabi (46%), training the teachers how to conduct practical work so that the learners are engaged in social construction of knowledge (38%) and the learners taking Higher level.

4.6.2 Results from interviews

The results that emerged from the interviews with the Biology and Physical Science teachers are presented under the following headings: training workshops, resources, support from Advisory teachers, improvisation, curriculum and class size.

4.6.2.1 Training workshops

In the interviews with the Biology and Physical Science teachers, one Biology teacher highlighted that training workshops should be organised for teachers on how to conduct practical work. This was his response:

Teacher T11 (Biology):

> *There is quite a lot that is needed to be done. For example, I wish training workshops can organized where teachers are refreshed on how to set up practicals, conduct practicals and how to draw up the worksheet that learners should be able to follow. So, the workshops to me are important.*

4.6.2.2 Resources

Also, in the interviews with the teachers, Biology and Physical Science teachers identified the provision of resources as one that could improve the teaching of practical work. Their responses were:

Teacher T11 (Biology)

> *We have got few secondary schools. I think they are just eleven in the region. So if these secondary schools can be well equipped in their laboratories in terms of providing them with chemicals and apparatus it can be of importance because these secondary schools could assist neighbouring schools within the circuit or within the clusters in which they are located. So the laboratories should be available and functional but not only as white elephants. They should be equipped with some materials that are needed..*

Teacher T12 (Physical Science):

We have to consider the availability of chemicals and the ordering of chemicals. Otherwise, we will be teaching theories (theoretical practicals).

4.6.2.3 Support from Advisory teachers

During the interviews, one Physical Science teacher suggested support from Advisory teachers as another means that might improve the teaching of practical work in senior secondary schools. This support would ensure that practicals are done in schools. These were their responses:

Teacher T12 (Physical Science):

We should involve the Advisory teachers to support the schools and ensure that the practicals are done as required by the syllabus.

Teacher T7 (Biology):

The government or regional offices must expand and equip our laboratories.

Teacher T13 (Physical Science):

The most crucial one is to make sure that the science laboratory is well equipped as required by the set standards.

Teacher T1 (Biology):

My concern is on equipments and also the types of laboratories that we should have. I think we should have modern laboratories that are well equipped, where chemicals are available but without equipments it will be difficulty to teach practicals.

Teacher T7 (Biology):

I suggest the school should take into account to provide the necessary equipments.

4.6.2.4 Improvisation

One Biology and one Physical Science teachers reported in the interview that teachers should have the knowledge of improvising. Thus, being resourceful in cases where equipments or chemicals are not available. The two teachers remarked that:

Teacher T13 (Physical Science):

> *The science teachers should have the knowledge of improvisation to meet the urgent needs.*

Teacher T1 (Biology):

> *In most cases, we teachers improvise whereby if one thing is not available then you look for another substitute just to enable learners to understand how things go. Because in real life, Biology is about life and is about what is happening. So sometimes we improvise by trying to go to real life situations.*

4.6.2.5 Curriculum

The teachers' responses about curriculum focused on the number of practicals in the syllabus as being too many. They suggested a reduction in the subject content to enhance and improve the teaching of practical work.

Teacher T7 *(Biology)*

> *The numbers of suggested practicals in the syllabus are too many. Sometimes, the practicals you have chosen to do with your learners do not come in the exams that year. So, the content is too much. I wish could be reduced.*

4.6.2.6 Class size

From the interview, Teacher T12 (Physical Science) and Teacher T7 (Biology) suggested that if the large number of learners in the classes could be reduced by building extra classrooms for a particular grade or upgrade some combined schools to senior secondary schools, it would improve the teaching of practical work because

the teachers might use the few resources to work with small groups of learners. The two teachers said:

Teacher T12 (Physical Science):

> *We really have large numbers of learners in the classrooms because we have few senior secondary schools and may be one way to reduce class population is to promote some combined schools to senior secondary schools. Then, we can have few learners in the class. With the few chemicals and apparatus we can work with small groups of learners. Maybe that will make the teaching of practical work possible.*

Teacher T7 (Biology)

> *It's very difficult to teach practicals to overcrowded classes that have many learners in small laboratories or classrooms. This problem is just continuing every year because the number of learners in our school is increasing every year. Imagine 400 learners for Biology alone with one lab. The government must build more laboratories in our school to accommodate these big numbers of learners. And the laboratories must be big.*

4.7 Discussion of the results

The purpose of the current study was to investigate the teaching of Biology and Physical Science practical work in senior secondary schools in the Zambezi Region vis-à-vis the learning objectives outlined in the subjects curriculum, the practical skills the Biology and Physical science teachers wanted their learners to achieve from the practical work they taught their learners, the assessment criteria used by the Biology and Physical Science teachers to assess the practical skills acquired by the learners and the teachers' views on what should be done to improve the teaching of practical work. The following is the discussion of the teaching of practical work and

the views of the teachers about the measures that could improve the teaching of practical work in senior secondary schools.

4.7.1 The teaching of Biology and Physical Science practical work in senior secondary schools in the Zambezi Region vis-à-vis the learning objectives outlined in the subjects' curricula

The study participants were of the view that they taught Biology and Physical Science practical work in the study area. The data from the questionnaires revealed that teachers taught practical work following the learning objectives outlined in the subjects' curricula. This result collaborate with the Natural Sciences Subject Policy Guide which expects Biology and Physical Science teachers to teach practical work that are prescribed in the syllabi for senior secondary schools (Ministry of Education, 2008a). Therefore, it is the duty of the teachers to teach practical work in order to equip learners with the competencies needed to pass their examinations.

The findings from the participants' interview indicated that all the teachers followed the learning objectives outlined in the syllabi to teach practical work. In general the teachers consulted their syllabi to check the suggested practical objectives.

In this study, all the fourteen teachers acknowledged the value of teaching practical work as it could help them (learners) to understand the contents well and remember what they have done with their hands. However, most of the teacher in the study taught practical work once in a week. This might be a critical problem that may affect the performance of the learners in the examinations if they are not frequently taught practical work. Hodson (1990) argued that the purpose of teaching practical work should be considered as helping the learners to acquire practical skills and be ready for the practical examinations. Therefore, in order for the learners to be prepared for the practical examinations, the teachers have to teach the required

practicals. Gott and Duncan (2003) also established that lack of practical work leads to poor performance of the learners in the practical examinations.

In this study, it was revealed that the practical lessons were not allocated the same teaching time in Biology and Physical science in all the secondary schools involved in the study. According to the National Subject Policy Guide for Natural Sciences (Ministry of Education, 2008a) the teaching of practical work will require a double period (consecutive periods) on the time-table to provide enough time for practical activities. The teachers' responses seemed to show that the teachers did not know why there were double periods on their time-tables. In other words, the Biology and Physical Science teachers were not using the double periods to teach practical work. If they were not using the double periods for practical work, then they should have been using them for theoretical lessons.

The use of a classroom or a laboratory could have an impact on the teaching of Biology and Physical Science practical work (Nghipandulwa, 2011). In this study, all the participants indicated that they used laboratories when teaching practical work. This suggests that all the secondary schools in the study have laboratories for teaching practical work. These findings were not consistent with the practical lessons observations, which revealed that the some teachers taught practical work in the normal classrooms. Researchers believe that the use of the laboratories in the teaching of practical work depends on the availability of teaching and learning resources. According to Hofstein and Lunetta (2004), the use of the laboratory in the teaching of practical work depends on the attitudes of the teachers towards practicals. Based on the teachers' responses in this study, it is fairly safe to assume that the

participants should embrace the use of both laboratories and classrooms in the teaching of practical work.

The participants expressed concern about the availability of teaching and learning resources for practical work. The results from the participants' questionnaires, practical lesson observation and interviews on the availability of resources were negative. It would appear that the secondary schools involved in the study in the Zambezi Region did not have enough resources in their science laboratories. Kandjeo-Marenga (2011), states that, most of the Namibian secondary schools have inadequate resources particularly in their science laboratories for teaching practical work. More than three quarters (11 out of 14) of the teachers, indicated that their secondary schools' laboratories did not have all the resources for teaching practical work (see Table 10). These findings were consistent with the practical lessons observations conducted by the researcher, which revealed that some of the laboratories for secondary schools that participated in the study did not have adequate facilities for teaching practical work (see Figure 5). Hodson (1990) argued that the unavailability of teaching materials, such as apparatus and chemicals, have negative effects on the teaching, which might suggest that the teaching of practicals is constrained in secondary schools where there are inadequate laboratory facilities. Ogunmade (2005) also report that the availability of teaching resources is important for effective teaching to take place. He adds that teaching cannot take place in the classrooms if basic teaching materials and equipments are not available. This means that if the secondary schools' laboratories did not have enough equipments and materials it might be difficult for teachers, particularly for Biology and Physical Science, to teach practical work.

The study participants indicated that they used demonstrations, groupwork, lecture method and investigations in their teaching of practical work. According to Borich (2007), teaching methods are the most important techniques employed by the teachers to achieve the objectives of a lesson. Al Maghraby and Alshami (2013) also indicated that science teachers need to use teaching methods which are flexible, creative and more learner-centred, in order to accommodate different learning styles of learners. Mawazo (2010) also indicated that teaching methods do make a difference in learners' performances.

Using teaching methods that involve learners socially actively in Biology and Physical Science such as group experiments and investigations could increase learning and subsequently the achievement of scientific skills. Taking learners out on fieldwork in places like Namibia Breweries will allow learners to have a deep understanding of some Biology and Physical Science concepts for example, enzymes and their uses in real life. This will help in memory retention.

These findings were consistent with the practical lesson observations conducted by the researcher, which revealed that the teaching methods used by the Biology and Physical science teachers in practical lessons included lecture method, group work, experiments and teacher demonstrations. Research indicates that the practice of presenting content through lecture method does little to foster constructive learning (Hierbert & Stigler, 2000). This way of teaching may disadvantage the learners because it minimizes social interactions among the learners. Constructive teaching requires learners to build on their prior knowledge at their own pace, flowed by group work. Group experiments are believed to be the heart of social constructivist

teaching. It is believed that if group work is integrated into collaborative learning, it may help the learners improve their acquisition of practical skills (Tekkaya, 2003).

4.7.2 Practical skills Biology and Physical Science teachers want the learners to achieve from the practical work they teach in senior secondary schools

Practical skills are competencies and process skills acquired while performing a scientific investigation (Bennet & Kennedy, 2001). The results from the participants' questionnaires on the practical skills they wanted the learners to achieve from the practical work they taught in senior secondary schools revealed that the most taught practical skills by the Biology and Physical science teachers were applying scientific knowledge and understanding to make interpretations and to draw appropriate conclusions from practical observations and data. Gott and Duncan (1995) consider the acquisition of such practical skills to be useful in learning because such skills deal with how learners can use different ideas to solve a scientific problem.

Millar (1999) suggests that teachers must teach learners an understanding of the practical skill. He argued that practical skills help learners to develop an understanding of the procedures of science.

The findings from the practical lesson observations conducted by the researcher showed different results in relation to what was indicated in the teachers' questionnaires. The practical lesson observations revealed that not all the prescribed skills were observed in the practical skills taught by the Biology and Physical Science teachers in the study area. The Biology and Physical Science teachers did not teach the application of knowledge and understanding skill. The activities given to the learners did not provide opportunity to them acquire the practical skills such as application of scientific knowledge and understanding (see Table 19). The observed

practical skills taught by the teachers included following sequence of instructions; handling apparatus and material competently; making and recording observations; as well as making and recording measurements accurately; handling and processing experimental data and carry out investigations. These results are supported by the participants' responses in the interviews. The teachers stressed the need for the leaners to know how to follow instructions and handle apparatus. However, teachers are supposed to teach all the prescribed practical skills. The findings from the study suggest that some Biology and Physical Science teachers showed difficulties in preparing and designing practical activities that could help the learners acquire certain practical skills.

4.7.3 Assessment criteria used by the Biology and Physical Science teachers to assess the practical skills acquired by the learners.

In this study, it was revealed that the assessment criteria used by the Biology and Physical Science teachers were handling and processing data, following instructions and making observations. The least used assessment criteria were the application of scientific knowledge and the planning and designing investigations. As the assessment of the learners' practical skills was concerned at the end of the practical lessons, it was found that assessment of practical skills was mainly in terms of post-practical work questions, written work and classwork. However, there was no evidence of assessment criteria for assessing the practical skills. Kelly (1989) pointed out that assessment of practical skills is fair criteria are devised and shared with the learners. The criteria are outlined in the Biology and Physical Science syllabi.

Assessment criteria are necessary in order to find out whether the learners understood what they have been taught from the practical work. Through assessment

criteria, the teachers might find out which practical skills the learner had a problem to acquire. Without assessment criteria such problems could remain unsolved resulting in poor performance on Paper 3.

The interview responses revealed that some Biology and Physical Science teachers seemed not to understand what assessment criteria meant and gave different examples regarding assessment criteria. For example, teacher T2 regarded criteria provided in the syllabus, whereas teacher T1 relied on his own understanding. The way the teachers explained the assessment criteria used revealed a patchy understanding of the assessment criteria outlined in both Biology and Physical Science syllabi. Thus, while the assessment criteria are outlined in the syllabi, there appear to be little understanding about what it entails and how it should be used to assess particular skills. It was evident from the interviews that the Biology and Physical Science teachers had some knowledge regarding assessment, but they lacked deep understanding of the criteria.

From the learners' workbooks, there was no evidence of assessment criteria for assessing the practical skills. According to Yung (2001), the absence of assessment criteria is an indication that teachers lack experience with assessment methods aimed at assessing learners' achievement of practical skills. As result teachers fail to devise schemes and criteria to assess achievement in experimental and investigative skills.

4.7.4 Teachers' suggestions for improving the teaching of Biology and Physical Science practical work in senior secondary schools in the Zambezi region

The study participants expressed that the strategies that could be done to improve the teaching of Biology and Physical Science practical work in the study area include teacher training, provision of resources, support from Advisory teachers, improvisation and reduction in the subject content and class sizes. According to

Muijs and Reynolds (2011), teachers need to be trained in order to apply effective teaching. It is clear from the results that some participants in the study area have indicated the need for training workshops on how to design, set up and carry out certain practicals.

The participants were also of the view that the provision of resources could improve the teaching of practical work. Beck and Earl (2002), reported that the provision of teaching and learning material is one the factors that could improve teaching and learning in schools. Lack of resources as revealed by the participants affect the teaching of practical work in the study area. This is supported by Kapenda (2008) where the author reported that lack of teaching resources is a factor that affects the teaching and learners' academic performance. Results from the questionnaires, practical lesson observations and interviews indicated that there are insufficient laboratory equipments, as well as dysfunctional laboratories in the study area. Kandjeo-Marenga (2008) reported that lack of practical teaching materials in schools is a concern. This might have an effect on the learners' academic performance because teachers will not teach effectively

Similar to the study's findings that the large content of Biology and Physical Science syllabi affect the teaching of practical work in the schools is reported by Nakanyala (2015). The participants suggested a reduction in the number of suggested practicals in the Biology and Physical Science syllabi to improve and enhance the teaching of practical work. It is therefore, important that the Biology and Physical Science content and the number of suggested practicals be reduced because when the content and number of practicals is small, it may give the teachers confidence to teach most of the practicals.

With regard to the overcrowded classrooms, the teachers suggested that if the large number of learners in the classes could be reduced by building extra classrooms and laboratories, it would improve the teaching of practical work because teachers might use few resources to teach small groups of learners. Smaller number of learners in the classrooms leads the teachers to use learner-centred approach such as group work which actively involve learners in the lesson (Amoonga & Kasanda, 2011). Individual learners may get better attention from the teacher.

The participants were also of the view that improvising of the limited resources could improve the teaching of practical work. This was also found by Hodson (1990) who reported that to improve the teaching of science, teachers should have the knowledge of improvising. Thus, being resourceful in cases where equipments or chemicals are not available

4.8 Summary

This chapter presented the findings from questionnaires, lesson observations, interviews and document analysis. The findings presented focussed on the teaching of Biology and Physical Science practical work in senior secondary schools Zambezi region. There were a few mismatches between the findings from the lesson observations and what the teachers provided in the questionnaires. A number of measures that could improve the teaching of practical work in Biology and Physical Science were identified.

The next chapter provides the summary, draws conclusions and makes recommendations with regards to the research questions.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter gives the summary, conclusions and recommendations arising from this study. The purpose of the study was to investigate the teaching of practical work in Biology and Physical Science in the senior secondary schools in the Zambezi region, Namibia. Finally, the possible areas for further research are also identified.

5.2 Summary

The main purpose of this study was to investigate the teaching of practical work in Biology and Physical Science in senior secondary schools in Zambezi Educational Region.

In this regard, four research questions were generated to guide the study.

- Did the teaching of Biology and Physical Science practical work in senior secondary schools in the Zambezi Region follow the learning objectives outlined in the subjects' curricula?
- What practical skills do the Biology and Physical Science teachers aim to achieve from the practical work being taught in the senior secondary schools?
- What assessment criteria are used by the Biology and Physical Science teachers to assess the practical skills acquired by the learners?
- What are the opinions of the Biology and Physical Science teachers on the things that should be done to improve the teaching of Biology and Physical Science practical work in senior secondary schools in the Zambezi region?

This study adopted a mixed methods research design and employed both qualitative and quantitative approaches to gather information about the teaching of Biology and Physical Science practical work in the senior secondary schools. The quantitative

data was collected through close ended questionnaires and document analysis, followed by the collection of qualitative data through interviews and lesson observations (see Appendices 7-12). Purposeful sampling method was used to select 7 Biology and 7 Physical Science teachers in 7 out of 10 senior secondary schools in the Zambezi region. A total of 7 Biology and 7 Physical Science teachers participated in the study. Thus, the sample consisted of fourteen teachers (made up of 7 Biology and 7 Physical Science teachers). All the teachers completed questionnaires after which they were observed in their lessons and interviewed.

The results of questionnaires and observation were analysed using descriptive statistics to determine the frequencies and percentages and these were presented using frequency tables and graphs. The qualitative data from the interviews were analysed using the content analysis technique and organised into categories guided by the research questions and themes that emerged from the study. Documents were analysed using the document analysis guide (DAG) (Appendix 13).

The results of the study revealed that the teaching of practical work in Biology and Physical Science in senior secondary schools in the Zambezi Region did not follow the guidelines as outlined in the subject curricula. Some teachers indicated that they taught practical work depending on the basic competencies and the topics which required practicals. The teachers indicated that although the schools had few chemicals, some chemicals were out-dated and expired. The results of the study also revealed that making and recording estimates, observations and measuring accurately were the most practical skills the Biology and Physical Science teachers taught and aimed to achieve from the practical work. Also predominant was learners following a sequence of instructions; using appropriate techniques and handling apparatus /

materials. It also emerged that recommended practical skills such as applying scientific knowledge and understanding to make interpretations and drawing appropriate conclusions from practical observations and data as well as planning, designing and carrying out investigations and suggesting modifications in the light of experience were the least taught skills by both the Biology and Physical Science teachers. Findings of the study also indicated that the teachers did not assess all practical skills. Both the Science teachers gave higher assessment weighting for practical skill C1 (handle apparatus competently), skills C2 (make observations; make measurements, record observations and measurements) and skills C3 (handle and process experimental observations and data).

The results of this study revealed that the Biology and Physical Science experienced various problems when teaching practical work. The identified problems include: the lack of apparatus, chemicals and equipments; small laboratory space; leaners' inability to interprete experimental results; learners not exposed to practical work from lower grades; lack of interest in practical activities and indiscipline, lack of communication and observation skills. In addition, overcrowded classrooms were the other problem experienced by the Biology and Physical Science teachers when teaching of practical work.

The Biology and Physical Science teachers suggested various ways of improving the teaching of practical work in the senior secondary schools in Zambezi Region. Notable among the suggestions given by the teachers include: provision of resources and equipments, organise training workshops for teachers on how to teach practical work, support from Advisory teachers of Biology and Physical Science,

improvisation when chemicals, apparatus and equipments are not available, reduction in number of suggested practical in the syllabus and reduction of the large numbers of learners in the classroom by upgrading combined schools to senior secondary schools. Furthermore, it was indicated that the directorate of education in the Zambezi Region should improve infrastructure by building and equipping more laboratories.

5.3 Conclusions

The study investigated the teaching of Biology and Physical Science practical work in senior secondary schools in the Zambezi Region. Information gathered from the questionnaire and interviews clearly demonstrates that the Biology and Physical science teachers rarely taught practical work. Based on the results of this study, it is clear that the teaching of practical work in senior secondary schools in the Zambezi Region was not done according to the learning objectives outlined in the subjects syllabi even though most of the Biology and Physical Science teachers said they did. According to Ajaja (2009) the teaching of practical work is most appropriate if it addresses the prescribed learning objectives. The teachers also did not provide opportunities for the learners to carry out practicals themselves even though learners were expected to do practicals under the guidance of the teacher. While the syllabi emphasizes the teaching of different practical skills, the teachers involved in the study placed emphasis on observations, recordings, measurements, application of scientific knowledge and drawing conclusions from practical observations. Lesson observations show that not all the prescribed practical skills were observed in the practical work the teachers taught the learners. If practical work has not been taught according to the guidelines in subjects' curricula, it can be safely implied and

concluded that the aims and objectives of practical work are not being achieved in the senior secondary schools in the Zambezi Region.

The finding of the lesson observations seemed to indicate that the schools' laboratories did not have adequate teaching resources and equipment for teaching practical work in Biology and Physical Science. Some of the laboratories had unlabelled and expired chemicals and thus could not be used to teach practical experiments. It is therefore apparent to imply that the lack of equipments, apparatus and chemical made it difficult for some Biology and Physical Science teachers to teach practical work in the study area. However, the observations also revealed that urban schools were better equipped compared to the rural senior secondary schools. This might be the reason that have compromised the teaching of practical work in rural senior secondary schools and ultimately the cause for the poor performance of learners in Paper 3.

Drawing on the findings from this study in terms of what assessment criteria the teachers used to assess practical skills acquired by the learners, the questionnaires responses showed that the most assessment criteria used by the Biology and Physical science teachers was application of scientific knowledge and following instructions. However, findings of the practical lesson observations indicated that teacher did not assess the learners at the end of the practical work, to determine if they had acquired the practical skills. Furthermore, the study found that the learners did not submit any work to the teacher for assessment. It can be implied that the absence of assessment of the practical skills at the end of the practical work negatively affected the

achievement of the envisaged objectives of the practical work. This might have adverse impact on learners' performance in Paper 3.

In contrast, results from the interviews shows that some teachers did not understand what was meant by assessment criteria and were not aware of the assessment criteria specified in the syllabi. The criteria in the NSSCO Biology and Physical science syllabi provide a clear guideline on how practical skills should be assessed. However, only one teacher highlighted assessment criteria with reference to the syllabus. Findings from document analyses showed that the teachers' lesson plans did not indicate assessment of practical skills. This seems to suggest that the teachers did not assess achievement of practical skills at the end of practical work. Learners' workbooks indicated that assessment of practical skills was mainly in terms of post-practical questions, written work, class work and past examination questions. However, there was no evidence of assessment criteria for assessing practical skills achieved by the learners. In the absence of assessment criteria, it can be concluded that the teachers seemed not to connect practical work they taught to the practical skills they intended their learners to achieve.

5.4 Recommendations

In light of the findings of this study, the following recommendations were made:

1. To make the teaching of Biology and Physical science practical work most appropriate, it is recommended that the teachers teach practical work according to the guidelines in the subjects' curricula and should address the specified objectives.
2. If the Biology and Physical Science teachers are to achieve the intended practical skills taught to their learners, they should aim at teaching all the

prescribed practical skills stipulated in the syllabi. The role of the teachers in this regard is to link practical work they teach to the practical skills they intend their learners to achieve.

3. To help Biology and Physical Science teachers in the assessment of practical skills acquired by the learners, training workshops and in-service training for the teachers should be held on a regular basis to train them on how to design practical activities, conduct practical work and the use of assessment criteria.
4. The researcher observed that some of the senior secondary schools in Zambezi region have a shortage of resources (e.g. chemicals, apparatus and equipments). Therefore, the Ministry of Education, Arts and Culture should provide adequate resources that are needed during practical lessons for better teaching and learning of practical work in the study area
5. The Biology and Physical Science Advisory teachers should regularly visit senior secondary schools in order to identify the problems that the teachers are experiencing in teaching practical work with a view to provide intervention measures.
6. Strict supervision as a way of quality assurance should be enforced to ensure that the teachers keep to the Time-Table Schedule and make use of the double lessons to teach practical work.
7. In view of the challenges of overcrowded classrooms both the Biology and Physical Science teachers face in the study area, the Ministry of Education should build more classrooms and laboratories and appoint more Biology and physical teachers to alleviate the problem, including the high learner to teacher ratio in the senior secondary schools.

8. Similar research should be conducted in schools in the other regions of Namibia especially where there are histories of learners' poor performances in Biology and Physical Science. This will help to generate nationwide information that may be necessary for government's urgent attention

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APPENDIX 1: Research permission letter

CENTRE FOR POSTGRADUATE STUDIES

University of Namibia, Private Bag 13301, Windhoek, Namibia
340 Mandume Ndemufayo Avenue, Pioneers Park
☎ +264 61 206 3275/4662; Fax +264 61 206 3290; URL: http//www.unam.edu.na

UNAM
UNIVERSITY OF NAMIBIA

RESEARCH PERMISSION LETTER

Student Name: LISWANISO J. LISWANISO

Student number: 9708464

Programme: Master of Education (Science Education)

Approved research title: An investigation of the quality of teaching practical works in Biology and Physical Science in the senior secondary schools in Zambezi Region, Namibia

TO WHOM IT MAY CONCERN

I hereby confirm that the above mentioned student is registered at the University of Namibia for the programme indicated. The proposed study met all the requirements as stipulated in the University guidelines and has been approved by the relevant committees.

The proposal adheres to ethical principles as per attached Ethical Clearance Certificate. Permission is hereby granted to carry out the research as described in the approved proposal.

Centre for Postgraduate Studies
Office of the Director
2018 -05- 21
University of Namibia
UNAM

Best Regards

Prof. Marius Hedimbi

Director: Centre for Postgraduate Studies

Tel: +264 61 2063275

E-mail: directorpgs@unam.na

APPENDIX 2: Letter requesting permission to the Permanent Secretary

P O BOX 543
Ngweze
Katima Mulilo
21 May 2018

The Permanent Secretary
Ministry of Education
Private Bag 13186
Windhoek

Dear Ms Steenkamp

RE: Request for Permission to conduct research in schools in Zambezi region

I am a registered student at the University of Namibia pursuing a Master's degree in Science Education. In fulfilment of the requirements for the completion of this degree, I am required to conduct a research project. I kindly request your office to allow me to use the senior secondary schools in the Zambezi region as my research sites.

My thesis topic is: **Investigating the teaching of Biology and Physical science practical works in senior secondary schools in the Zambezi region.**

The first phase of the research project will involve distributing questionnaires to all grade 11 and 12 teachers in ten senior secondary schools in the Zambezi region offering NSSCO Biology and Physical science. The second phase of the research will involve five schools and a total of ten teachers chosen on the basis of the results of the first phase of the research. These will participate in observation and interview. The information gathered will be treated with confidentiality and will be used solely for the purpose of research.

I hope that the results of this study will positively contribute towards improving the teaching of Biology and Physical science practical works in our secondary schools in Zambezi Educational region as it will help discover some of the problems that might have not been identified by education stakeholders thereby improving learner performance.

Should you have any queries about this request, please contact my Supervisor Dr. J Abah at +264 66 262 6000, Email: jabah@unam.na

I thank you in advance for your support in this matter.

Yours in education

Mr. Liswaniso Joseph Liswaniso
MASTER OF SCIENCE EDUCATION

APPENDIX 3: Approval letter from the Permanent secretary

REPUBLIC OF NAMIBIA

MINISTRY OF EDUCATION, ARTS AND CULTURE

Enquiries: C. Muchila/ G. Munene
Tel: +264 61 -2933200
Fax: +264 61- 2933922
Email: Cavin.Muchila@moe.gov.na/gm12munene@yahoo.co.uk

Luther Street, Govt. Office Park
Private Bag 13186
Windhoek
Namibia

File no: 11/1/1

To: Mr. Liswaniso Joseph Liswaniso
Po Box 543
Ngweze
Katima Mulilo

Dear Mr. L. J. Liswaniso

SUBJECT: PERMISSION TO CONDUCT RESEARCH IN ZAMBEZI REGION.

Kindly be informed that permission to conduct an academic research for your Master's Degree in Science Education on "*Investigating the teaching of Biology and Physical Science Practical works*" in the Senior Secondary Schools in the Zambezi Region, is here with granted. You are further requested to present the letter of approval to the Regional Director of Education, Arts and Culture to ensure that research ethics are adhered to and disruption of curriculum delivery is avoided.

Furthermore, we humbly request you to share your research findings with the ministry. You may contact Mr C. Muchila/ Mr. G. Munene at the Directorate: Programmes and Quality Assurance (PQA) for provision of summary of your research findings.

I wish you the best in conducting your research and I look forward to hearing from you soon.

Sincerely yours

SANET L. STEENKAMP
PERMANENT SECRETARY

Ministry of Education, Arts and Culture
Office of the Permanent Secretary
2018 -06- 13
Private Bag 13186
Windhoek, Namibia

13/6/18
Date

All official correspondences must be addressed to the Permanent Secretary

APPENDIX 4: Letter requesting permission to Regional Education Director

P O BOX 543
Ngweze
Katima Mulilo
16 June 2018

The Regional Director
Directorate of Education
Private Bag 5002
Katima Mulilo

RE: Request for Permission to conduct research in schools in Zambezi region

I am a registered student at the University of Namibia pursuing a Master's degree in Science Education. In fulfilment of the requirements for the completion of this degree, I am required to conduct a research project. I kindly request your office to allow me to use the senior secondary schools in the Zambezi region as my research sites for the research project.

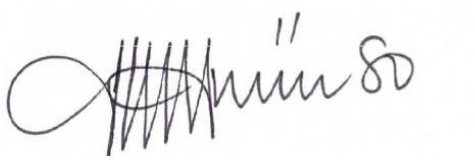
I have already sought permission from the Permanent Secretary in the Ministry of Education in Windhoek as per letter attached. My thesis focuses on **Investigating the teaching of Biology and Physical science practical works in senior secondary schools in the Zambezi region.**

The first phase of the research project will involve distributing questionnaires to all grade 11 and 12 teachers in ten senior secondary schools in the Zambezi region offering NSSCO Biology and Physical science. The second phase of the research will involve five senior secondary schools and a total of ten teachers (5 Biology and 5 Physical science teachers) chosen on the basis of the results of the first phase of the research. These will participate in observation and interview. The information gathered will be treated with confidentiality and will be used solely for the purpose of research.

I hope that the results of this study will positively contribute towards improving the teaching of Biology and Physical science practical works in our secondary schools in Zambezi Educational region as it will help discover some of the problems that might have not been identified by education stakeholders thereby improving learner performance.

I thank you in advance for your support in this matter.

Yours in education



Mr. Liswaniso Joseph Liswaniso
MASTER OF SCIENCE EDUCATION

APPENDIX 5: Approval letter from the Regional Education Director

REPUBLIC OF NAMIBIA
ZAMBEZI REGIONAL COUNCIL
DIRECTORATE: EDUCATION, ARTS AND CULTURE

Tel: +26466261902/964 *Ngoma Road* *Private Bag 5006*
Fax: +26466253187 *Govt Building* *Katima Mulilo, Namibia*

Enquiries: Adrenah Mukela ***Our Ref. No.:*** ***04 July 2018***

PO Box 543
Ngweze
Katima Mulilo
Namibia

Dear Mr Liswaniso Joseph Liswaniso

RE: PERMISSION TO CONDUCT RESEARCH IN SCHOOLS IN ZAMBEZI REGION

Reference is made to your letter dated 26 June 2018 in the subject context above.

Kindly be informed that approval is granted to you to visit schools to conduct a research to investigate the teaching of Biology and Physical Science practical works in Senior Secondary Schools in Zambezi Region, but let me draw your attention to the following aspects: **NOTE!**

a) The granted approval should not disrupt the normal teaching and learning at those schools you intend visiting.

b) Ministry of Education, Zambezi Region hereby would like to request you to share your findings with the Directorate.

By copy of this letter the Inspector of Education is notified accordingly of your presence in the schools.

I trust and hope you will find this in order.

MR JOSEPH J KAWANA
ACTING REGIONAL DIRECTOR: EAC

APPENDIX 6: Informed Consent Form for Teachers

Informed consent Form

Study name: An investigation of the teaching practical work in biology and Physical Science in senior secondary schools in the Zambezi region, Namibia.

Researcher: My name is Liswaniso Joseph, a Master of Education (Science Education) student at the University of Namibia. Currently, I am a Biology Ordinary level teacher at Caprivi Senior Secondary School, Email: liswajoe@gmail.com

Purpose of research: The aim of this study is to investigate the teaching of Biology and Physical Science practical work in senior secondary schools and to recommend strategies that can be used to improve the teaching of Biology and Physical Science practical work in the Zambezi Region, Namibia.

What you will be asked to do in the research: I would like to observe you teach a practical lesson and interview you after you have taught all the work that you will plan from the syllabus. The interview, to be conducted at the very end of your teaching will last about 10 minutes.

Risks and discomforts: There are no risks or discomfort in this study hence, your honest and valued opinion is required.

Benefits of the research and benefits to you: This study seeks to understand the teaching of practical work in our secondary schools and is not for evaluation or reporting purposes. The research will benefit you and other stakeholders by providing detailed information on the teaching of practical work in NSSC Ordinary level Biology and Physical Science and provide useful recommendations that could help teachers to improve and strengthen the teaching of practical work in senior secondary schools.

Voluntary participation: Your participation in this study is completely voluntary and you may stop participating in the study at any time, for any reason, if you so decide. Your decision to stop participating, or to refuse to answer particular questions, will not affect your relationship with the researcher or the University of Namibia.

Withdrawal from the study: In the event you withdraw from the study, all associated data collected will be immediately destroyed wherever possible.

Confidentiality: Confidentiality and anonymity will be provided to the fullest extent possible by upholding a high level of privacy and by law. The collected raw data through questionnaires, observation schedules and interviews, will be accessible only to the researcher. The data will be stored and kept in a safe place and on a computer with a security code for two year before destroying them. To ensure anonymity and protection of your identity and that of your school, I will not identify you by your actual names in the thesis. Both your school and you will be given codes for identification.

Questions about the research

If you have any questions about this study or about your role as a participant in the study, you may contact me, the researcher or my research supervisors: Dr James Abah, Tel: 0662626128, Email: jabah@unam.na,; Dr Hedwig Kandjeo-Marenga, Tel: 061-2063287, Email: hukandjeo@unam.na

This research has been reviewed and approved by the University of Namibia Research Ethics Committee (IUREC) and conforms to the standards of the Research Ethics Committee guidelines.

Legal rights and signatures:

I, ……., consent to participate in the study "An investigation of the teaching practical work in biology and Physical

Science in senior secondary schools in the Zambezi region, Namibia" .conducted by Liswaniso Joseph. I have understood the nature of this project and wish to participate. I am not waiving any of my legal rights by signing this form. My signature below indicates my consent.

…… **Date: ……..... Participant Signature**

…… **Date: …….. Researcher Signature**

APPENDIX 7: Teacher questionnaire for Biology teachers

UNIVERSITY OF NAMIBIA
MATHEMATICS, SCIENCE AND SPORT EDUCATION

BIOLOGY TEACHERS' QUESTIONNAIRE

Dear Teacher

This questionnaire is designed with the aim of **INVESTIGATING THE TEACHING OF PRACTICAL WORK IN BIOLOGY AND PHYSICAL SCIENCE IN THE SENIOR SECONDARY SCHOOLS IN ZAMBEZI REGION, NAMIBIA.**

The questionnaire seeks your opinions about the teaching of practical work. There is no right or wrong answer to each question. Information from this questionnaire will be used to understand the way practical work are taught in selected senior secondary schools in the Zambezi region and improve the teaching of practical work in our senior secondary schools.

This is an anonymous questionnaire. Do not write your name on any part of this questionnaire.

Thank you in advance for your helpful participation

Most Sincerely,

Liswaniso J. Liswaniso
Postgraduate Student
Department of Mathematics, Science and Sport Education
Program: Master of Education (Science Education)

Questionnaire

An investigation of the teaching of practical work in Biology and Physical Science in the senior secondary schools in Zambezi region, Namibia.

Please check/tick ( ) or fill in the one description that mostly applies to you.

Section A

Please write your personal details in the following

1. Gender

Male	Female

2. Age

3. Teaching experience (in years)

4. Qualification

BETD	
B.ED	
HED	
M.ED	
Other (specify)	

5. Grade you are teaching

11	12

6. Number of learners ……

Section B

This section asks you about how Biology practical work are taught by the subject teachers in senior secondary schools.

1 Do you use practical work in your teaching of biology?

Yes	
No	

2 How often do you teach practical work in your biology subject?

Once a week	
Once every lesson	
Once in two lessons	
Rarely	
Never	
Others, (specify)	

3 What teaching time is allocated to practical work lesson in Biology?

40 minutes	
80 minutes	
Others (Specify)	

4 Do you use a classroom or laboratory when teaching practical work?

Classroom	
Laboratory	

5 What is your aim of teaching practical work to your learners? Please rank these in order of importance from 1 to 10. The most important should be ranked '1' and '10' the least aim should be ranked '10'.

Aim of teaching practical work	**Rank**
1. To enhance conceptual understanding	
2. To enhance investigative skills	
3. To enhance procedural knowledge about experiments	
4. To motivate, stimulate and maintain interest in biology	
5. To develop certain scientific attitudes and manipulative skills	
6. To enhance the learning of scientific knowledge	
7. To encourage accurate observations and descriptions of objects	
8. To promote a logical scientific reasoning method of in solving problems	
To verify or clarify facts and principles taught in theoretical lessons	
To make biological phenomena more real through actual experience	

6 Do you have enough materials and equipments to teach Biology practical work?

Yes	
No	

7 What type of practical work do you teach to your learners to achieve the development of practical skills?

Investigations	
Experiments	
Fieldwork	
Problem solving activities	
Projects	
Exercises	
Excursion	
Demonstrations	

8 What do you perceive as teaching of practical work in Biology?

	All the time	**Most of the time**	**Some time**	**Not often**	**Never**
a) Learners must carefully follow the teacher's instructions for experiments to reach the correct conclusions					
b) Learners plan their own experiments to investigate their own questions					
c) Whole-class discussion occurs at the conclusion of activities to summaries the main ideas					
d) Practical work is used to illustrate the concepts that have been introduced					
e) Practical work is carried out by learners before the theory is introduced					

f) Learners do hands-on practical work every week					

9 Which of the following do you use in teaching Biology practical work?

Lecture method	
Demonstrations	
Group work	
Experiments	
Investigations	

Section C

This section is about practical skills the Biology teachers aim to achieve from the practical works they teach in senior secondary schools.

1 What practical skills do you teach during practical work?

……
……
……
…….

2 What is your (teacher) role during Biology practical work?

……
……
……
……
……
……

3 What do your learners do during actual practical lessons?

……

……

……

……

……

……

……

4 Do your learners have a laboratory manual?

Yes	
No	

Section D

In this section, you are asked about the assessment criteria used by the Biology teachers to assess the practical skills acquired by the learners.

1. For what do you assess your learners at the end of the Biology practical lesson?

a) following a sequence of instructions; using appropriate techniques; handling apparatus/material competently and having due regard to safety	
b) making and recording estimations, observations and measurements accurately	
c) handling and processing experimental observations and data, including dealing with anomalous or inconsistent results	
d) applying scientific knowledge and understanding to make interpretations and to draw appropriate conclusions from practical observations and data	
e) planning, designing and carrying out investigations (based on concepts familiar to learners) and suggesting modifications in the light of experience	

2. How do you assess your learners at the end of the Biology practical lesson?

Written practical tests	

Post laboratory questions	
projects	
Practical report	

3. What assessment criteria do you use to assess Biology practical skills?

……
……
……
……
……

4. What practical skills are assessed by practical work carried out by your learners?

……
……
……
……
……
……

Section E

In this section, you are asked about what could be done to improve the teaching of Biology practical works in senior secondary schools.

1 What are your opinions about the teaching of practical work in your school?

……
…….....
.....
.....

2 What problems do you experience when teaching practical work to your learners?

……

……

……

……

3 How do these problems affect the teaching of practical works in Biology?

……

……

……

……

……

4 What do you think should be done to improve the teaching of Biology practical works in senior secondary school in the Zambezi region?

……

……

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……

……

……

Thank you very much for your time and contribution!

APPENDIX 8: Teacher questionnaire for Physical Science teachers

UNIVERSITY OF NAMIBIA
MATHEMATICS, SCIENCE AND SPORT EDUCATION

PHYSICAL SCIENCE TEACHERS' QUESTIONNAIRE

Dear Teacher

This questionnaire is designed with the aim of **INVESTIGATING THE TEACHING OF PRACTICAL WORKS IN BIOLOGY AND PHYSICAL SCIENCE IN THE SENIOR SECONDARY SCHOOLS IN ZAMBEZI REGION, NAMIBIA.**

The questionnaire seeks your opinions about the teaching of practical works. There is no right or wrong answer to each question. Information from this questionnaire will be used to understand the way practical works are taught in selected senior secondary schools in the Zambezi region and improve the teaching of practical works in our senior secondary schools.

This is an anonymous questionnaire. Do not write your name on any part of this questionnaire.

Thank you in advance for your helpful participation

Most Sincerely,

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Program: Master of Education (Science Education)

Questionnaire

An investigation of the teaching of practical works in Biology and Physical Science in the senior secondary schools in Zambezi region, Namibia.

Please check/tick ( ) or fill in the one description that mostly applies to you.

Section A

Please write your personal details in the following

1. Gender

Male	Female

2. Age

3. Teaching experience (in years)

4. Qualification

BETD	
B.ED	
HED	
M.ED	
Other (specify)	

5. Grade you are teaching

11	12

6. Number of learners ……

Section B

This section asks you about how Physical Science practical works are taught by the subject teachers in senior secondary schools.

1. Do you use practical work in your teaching of Physical Science?

Yes	
No	

2. How often do you teach practical work in your Physical Science subject?

Once a week	
Once every lesson	
Once in two lessons	
Rarely	
Never	
Others (specify)	

3. What teaching time is allocated to practical work lesson in Physical Science?

40 minutes	
80 minutes	
Others (Specify)	

4. Do you use a classroom or laboratory when teaching practical work?

Classroom	
Laboratory	

5. What is your aim of teaching practical work to your learners? Please rank these in order of importance from 1 to 10. The most important should be ranked '1' and '10' the least aim should be ranked '10'.

	Rank
1. To enhance conceptual understanding	
2. To enhance investigative skills	
3. To enhance procedural knowledge about experiments	
4. To motivate, stimulate and maintain interest in Physical Science	
5. To develop certain scientific attitudes and manipulative skills	
6. To enhance the learning of scientific knowledge	
7. To encourage accurate observations and descriptions of objects	
8. To promote a logical scientific reasoning method of in solving problems	
9. To verify or clarify facts and principles taught in theoretical lessons	
10. To make biological phenomena more real through actual experience	

6. Do you have enough materials and equipments to teach Physical Science practical work?

Yes	
No	

7. What type of practical work do you teach to your learners to achieve the development of practical skills?

Investigations	
Experiments	
Fieldwork	
Problem solving activities	
Projects	
Exercises	
Excursion	
Observations	

8. What do you perceive as teaching of practical work in Physical Science?

	All the time	**Most of the time**	**Some time**	**Not often**	**Never**
g) Learners must carefully follow the teacher's instructions for experiments to reach the correct conclusions					
h) Learners plan their own experiments to investigate their own questions					
i) Whole-class discussion occurs at the conclusion of activities to summaries the main ideas					
j) Practical work is used to illustrate the concepts that have been introduced					
k) Practical work is carried out by learners before the theory is introduced					

l) Learners do hands-on practical work every week					

9. Which of the following do you use in teaching Biology practical works?

Lecture method	
Demonstrations	
Group work	
Experiments	
Investigations	

Section C

This section is about practical skills the Physical Science teachers aim to achieve from the practical works they teach in senior secondary schools.

1. What practical skills do you teach during practical work?

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2. What is your (teacher) role during Physical Science practical work?

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3. What do your learners do during actual practical lessons?

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4. Do your learners have a laboratory manual?

Yes	
No	

Section D

In this section, you are asked about the assessment criteria used by the Physical Science teachers to assess the practical skills acquired by the learners.

1. For what do you assess your learners at the end of the Physical Science/Physical Science practical lesson?

a) following a sequence of instructions; using appropriate techniques; handling apparatus/material competently and having due regard to safety	
b) making and recording estimations, observations and measurements accurately	
c) handling and processing experimental observations and data, including dealing with anomalous or inconsistent results	
d) applying scientific knowledge and understanding to make interpretations and to draw appropriate conclusions from practical observations and data	
e) planning, designing and carrying out investigations (based on concepts familiar to learners) and suggesting modifications in the light of experience	

2. How do you assess your learners at the end of the Physical Science practical lesson?

Written practical tests	

Post laboratory questions	
projects	
Practical report	

3. What assessment criteria do you use to assess Physical Science practical skills?

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4. What practical skills are assessed by practical work carried out by your learners?

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Section E

In this section, you are asked about what could be done to improve the teaching of Physical Science practical works in senior secondary schools.

1. What are your opinions about the teaching of practical work in your school?

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…….....
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2. What problems do you experience when teaching practical work to your learners?

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3. How do these problems affect the teaching of practical works in Physical Science?

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4. What do you think should be done to improve the teaching of Physical Science practical works in senior secondary school in the Zambezi region?

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Thank you very much for your time and contribution!

APPENDIX 9: Observation schedule for Biology practical lesson

BIOLOGY PRACTICAL LESSON OBSERVATION INSTRUMENT

Name of Observer: _____

Name of School (CODE): _____

Class / Grade being observed: _____

Number of learners attending the Biology practical lesson_____

Duration of the practical lesson _____

Date of Observation: _____

Topic of practical lesson: _____

Objective of practical lesson _____

_____

Classroom / laboratory setting

1. Is the practical lesson taking place in the Biology laboratory or class?

Biology laboratory	
Biology class	

Other (specify) ……

2. Is the laboratory / classroom large enough for all learners during the practical lesson?

Yes	
No	

3. What is the condition of the Biology laboratory / classroom?

Tidy (clean)	
Well organized	
Enough space learners can move freely	
Rich visual displays	

4. Availability of practical work teaching / learning resources and equipment or items.

Items	**Sufficient**	**Insufficient**
Tables		
Chairs		
Textbooks		
Exercise books		
Laboratory facilities (e.g. apparatus and equipments)		
State of laboratory equipment		
Supply of chemical reagents		
Laboratory safety wears (e.g. lab coat)		

5. How is the Biology laboratory or class arranged?

Big circle	
Semi-circle	
Small groups	
Rows and columns	
Random	

6. How are the learners grouped / seated?

Individual	
Pair	
Group	

7. Which of the following does the teacher use in teaching Biology practical works of the lesson being observed?

Lecture method	
Demonstrations	
Group work	
Experiments	
Investigations	

8. Teachers' role during teaching and learning of practical works.

Statements	**Yes**	**No**
a. Teacher attends to individual learner's problem.		
b. Teacher facilitates the teaching / learning process by moving around laboratory / class giving assistance during practical work.		

c. Teacher dominates the teaching/learning process most of the lesson.		
d. Teacher provides short well planned notes to learners.		
e. Teacher provides appropriate feedback orally and in writing		
f. Teacher ensures that practical activities support the achievement of practical skills as indicated in the syllabus.		
g. Teacher ensures practical work is marked and corrections on mistakes are made.		
h. Teacher carries out demonstration / activity/ prepare solutions		
i. Teacher describes what is to be observed		
j. Teacher provides assistance to learners to carry out activity		
k. Teacher explains procedures to be followed to complete an experiment		
l. Teacher reads instructions for the practical activity		
m. Teacher asks learners to prepare / complete a table, a graph		
n. Teacher asks probing questions for meanings / check learner understanding		

9. Learner interaction and activities (What learners are doing)

	Yes	**No**
(a) Learners follow instructions for experiments in practical work		
(b) Learners plan and design their own experiments.		
(c) Whole-class discusses conclusions of practical activities.		
(d) Learners use practical work to illustrate the concepts that have been introduced		
(e) Learners carry out Practical work / experiments		
(f) Learners discuss the results after the experiment.		
(g)) Learners watch the teacher do an experiment		
(h)) Learners work in groups with others doing practical work		
(i)) Learners listen to the teacher explaining results		
(j)) Learners use apparatus / materials		
(k)) Learners make and record observations and measurements		
(l)) Learners process experimental observations and data		
(m)) Learners interprete and draw conclusions from practical observations /data		

10. Practical skills the Biology teacher teach their learners

	The learners	**Yes**	**No**
1	Follow a sequence of instructions; use appropriate techniques; handle apparatus/material competently and have		

	due regard for safety		
2	Make and record estimates, observations and measurements		
3	Handle and process experimental observations and data, including dealing with anomalous or inconsistent results		
4	Apply scientific knowledge and understanding to make interpretations and to draw appropriate conclusions from practical observations and data		
5	Plan, design and carry out investigations and suggest modifications in the light of experience		

APPENDIX 10: Observation schedule for Physical Science practical lesson

PHYSICAL SCIENCE PRACTICAL LESSON OBSERVATION INSTRUMENT

Name of Observer: _____

Name of School (CODE): _____

Class / Grade being observed: _____

Number of learners attending the Physical Science practical lesson_____

Duration of the practical lesson _____

Date of Observation: _____

Topic of practical lesson: _____

Objective of practical lesson _____

_____

Classroom / laboratory setting

1. Is the practical lesson taking place in the Physical Science laboratory or class?

Physical Science laboratory	
Physical Science class	

Other (specify) ……

2. Is the laboratory / classroom large enough for all learners during the practical lesson?

Yes	
No	

3. What is the condition of the Physical Science laboratory / classroom?

Tidy (clean)	
Well organized	
Enough space learners can move freely	
Rich visual displays	

4. Availability of practical work teaching / learning resources and equipment or items.

Items	**Sufficient**	**Insufficient**
Tables		
Chairs		
Textbooks		
Exercise books		
Laboratory facilities (e.g. apparatus and equipments)		
State of laboratory equipment		
Supply of chemical reagents		
Laboratory safety wears (e.g. lab coat)		

5. How is the Physical Science laboratory or class arranged?

Big circle	
Semi-circle	
Small groups	
Rows and columns	
Random	

6. How are the learners grouped / seated?

Individual	
Pair	
Group	

7. Which of the following does the teacher use in teaching Physical Science practical works of the lesson being observed?

Teaching method	
Lecture method	
Demonstrations	
Group work	
Experiments	
Investigations	

8. Teachers' role during teaching and learning of practical works.

Statements	**Yes**	**No**
a) Teacher attends to individual learner's problem.		
b) Teacher facilitates the teaching / learning process by moving around laboratory / class giving assistance during practical work.		
c) Teacher dominates the teaching/learning process most of the lesson.		

d) Teacher provides short well planned notes to learners.		
e) Teacher provides appropriate feedback orally and in writting.		
f) Teacher ensures that practical activities support the achievement of practical skills as indicated in the syllabus.		
g) Teacher ensures practical work is marked and corrections on mistakes are made.		
h) Teacher carries out demonstration / activity/ prepare solutions		
i) Teacher describes what is to be observed		
j) Teacher provides assistance to learners to carry out activity		
k) Teacher explains procedures to be followed to complete an experiment		
l) Teacher reads instructions for the practical activity		
m) Teacher asks learners to prepare / complete a table, a graph		
n) Teacher asks probing questions for meanings / check learner understanding		

9. Learner interaction and activities (What learners are doing)

	Yes	**No**
a) Learners follow instructions for experiments in practical work		
b) Learners plan and design their own experiments.		
c) Whole-class discusses conclusions of practical activities.		
d) Learners use practical work to illustrate the concepts that have been introduced		
e) Learners carry out Practical work / experiments.		
f) Learners discuss the results after the experiment.		
g) Learners watch the teacher do an experiment		
h) learners work in groups with others doing practical work		
i) Learners listen to the teacher explaining results.		
j) Learners use apparatus / materials		
k) Learners make and record observations and measurements		
l) Learners process experimental observations and data		
m) Learners interprete and draw conclusions from practical observations /data		

10. Practical skills the Physical Science teacher teach their learners

	The learners	**Yes**	**No**
1	Follow a sequence of instructions; use appropriate techniques; handle		

	apparatus/material competently and have due regard for safety		
2	Make and record estimates, observations and measurements		
3	Handle and process experimental observations and data, including dealing with anomalous or inconsistent results		
4	Apply scientific knowledge and understanding to make interpretations and to draw appropriate conclusions from practical observations and data		
5	Plan, design and carry out investigations and suggest modifications in the light of experience		

APPENDIX 11: Interview protocol for Biology teachers

INTERVIEW PROTOCOL FOR BIOLOGY TEACHERS

Preamble: Thank you Sir / Madam. The purpose of this interview is for us to discuss the teaching of Biology practical works in our senior secondary school. I would like us to look into what actually is happening in our secondary school and try to provide answers to the following questions. Though, I may have some other additional questions along the line.

1. What are your views about the teaching of practical work in your school?
2. How would you describe the teaching of Biology practical works in your school at the present time?
3. Do you teach practical works to your learners?
4. How do you teach practical works to your learners?
5. Does your teaching of practical works follow the learning objectives outlined in the subjects' curricula?
6. What practical skills do you aim to achieve from the practical works you teach your learners?
7. What criteria do you use to assess the practical skills you teach your learners?
8. What are your opinions on the things that should be done to improve the teaching of Biology practical works in senior secondary schools?

Thank the individual for participating in the interview.

APPENDIX 12: Interview protocol for Physical Science teachers

INTERVIEW PROTOCOL FOR PHYSICAL SCIENCE TEACHERS

Preamble: Thank you Sir / Madam. The purpose of this interview is for us to discuss the teaching of Physical Science practical works in our senior secondary school. I would like us to look into what actually is happening in our secondary school and try to provide answers to the following questions. Though, I may have some other additional questions along the line.

1. What are your views about the teaching of practical work in your school?
2. How would you describe the teaching of Physical Science practical works in your school at the present time?
3. Do you teach practical works to your learners?
4. How do you teach practical works to your learners?
5. Does your teaching of practical works follow the learning objectives outlined in the subjects' curricula?
6. What practical skills do you aim to achieve from the practical works you teach your learners?
7. What criteria do you use to assess the practical skills you teach your learners?
8. What are your opinions on the things that should be done to improve the teaching of Physical Science practical works in senior secondary schools?

Thank the individual for participating in the interview.

APPENDIX 13: Document analysis guide (DAG)

DOCUMENT ANALYSIS GUIDE (DAG)

Category	Comments	Source
Type of practical work		
Practical learning objectives		
Teaching method		
Practical skills taught		
Practical skills assessed		
Assessment criteria		

APPENDIX 14: Statements on the Likert scale and their codes

Statement	Code
Learners must carefully follow the teacher's instructions for experiments to reach the correct conclusions	P1
Learners plan their own experiments to investigate their own questions	P2
Whole-class discussion occurs when concluding the activities and summarizing the main ideas	P3
Practical work is used to illustrate the concepts that have been introduced	P4
Practical work is carried out by learners before the theory is introduced	P5
Learners do hands-on practical work every week	P6

Appendix 15: Practical skills taught by Biology and Physical Science teachers

Teacher	Subject	Practical skills taught by Biology and Physical Science teachers
T1	Biology	Following instructions **(C1)**, drawing conclusions from experiments **(C4)**
T2	Physical Science	Investigative skills **(C5)**, applying scientific knowledge **(C4)**, problem solving **(C5)**
T3	Biology	Observations**(C2)**, doing and writing
T4	Physical Science	Experimental procedures **(C1)**, handling apparatus **(C1)**, Observations **(C2)**, processing observations **(C3)**
T5	Biology	Observations **(C2)**, measuring **(C2)**, drawing **(C3)**, using beakers **(C1)**, processing data **(C3)**
T6	Physical Science	Collecting data **()**, recording data **(C2)**, processing data **(C3)**, presenting data **(C3)**
T7	Biology	Following instructions **(C1)**, recording **(C2)**, measuring **(C1),** applying **(C5),** investigating **(C5),** experimenting
T8	Physical Science	Making observations **(C2)**, following instructions **(C1)**, learning outcomes.
T9	Biology	Following instructions**(C1)**, observation **(C2)**, deductions **(C4)**, processing results **(C3)**,
T10	Physical Science	Understanding, hands-on skills**(C1)**, presenting records and results **(C3)**

T11	Biology	Handling and knowledge**(C1)**, discussion, observing **(C2)**, measuring **(C2)**, concluding
T12	Physical Science	Reading instruments**(C2)**, recording**(C2)**, working with instruments**(C1)** , following instructions**(C1)**
T13	Biology	Interpreting skills, drawing skills**(C2)** , writing skills **(C2)**, concluding results **(C4)**, observing**(C2)**
T14	Physical Science	Filtering and titration **(C1)**

APPENDIX 16: Teacher's role during practical work lesson

Teacher	Subject	Teachers' role during practical work lesson
T1	Biology	Help learners understand the steps / procedures of the experiment, ask challenging questions
T2	Physical Science	Provide equipments, give instructions, go around to oversee the practical activity
T3	Biology	Plan practical work, set clear guidelines / procedures, supervise, monitor, give correct feedback
T4	Physical Science	Demonstrate, explain what learners should do on the experiment
T5	Biology	Facilitator, demonstrate how the experiment is done, move around to see if learners are doing the right things
T6	Physical Science	Demonstrate using chemicals, explain procedures, summarise by issuing worksheets, explain how the lab-report should be
T7	Biology	Facilitator, evaluator, guide, monitor
T8	Physical Science	Teach and guide the learners. Motivate the learners.
T9	Biology	Provide worksheets and instructions
T10	Physical Science	Give quality instructions, make sure learners are involved
T11	Biology	Give hand outs of practical activity, demonstrate to the learners, facilitate discussions
T12	Physical Science	Provide/arrange equipments to groups, observe the learners doing experiment, demonstrate
T13	Biology	Teach the learners, give homework, give feedback
T14	Physical Science	Assist learners, explain unclear instructions/procedures

APPENDIX 17: Learner activities during practical lessons

Teacher	Subject	What learners did during practical work lesson
T1	Biology	Follow instructions, make observations, recording, analysing results, draw conclusions.
T2	Physical Science	Assemble apparatus, carry out practical activities, make observations, and tabulate data, process information.
T3	Biology	Follow instructions /procedures and draw conclusions.
T4	Physical Science	Get involved and ask for support/help
T5	Biology	Follow worksheet instructions
T6	Physical Science	Read through the practical instructions/protocol and do the practical on their own.
T7	Biology	Carry out experiments / investigations stated in the syllabus under suggestion for practicals
T8	Physical Science	Observe and record experimental results, learn to handle and use apparatus, and interprete results.
T9	Biology	Carry out practical activities, demonstrates, answer questions.
T10	Physical Science	Do the actual practical activity, record the results and handle apparatus.
T11	Biology	Observe what the teacher is doing, complete worksheets, discuss results, measure volumes, answer experimental questions, and draw graphs.
T12	Physical Science	Handling and connecting the apparatus, make observations.
T13	Biology	Observe and follow the instructions as being told by their teacher.
T14	Physical Science	They do nothing because we don't chemicals to do practicals.

APPENDIX 18: Problems experienced by Biology and Physical Science teachers when teaching practical works in the study area.

Teacher	Subject	Problems experienced when teaching practical works
T1	Biology	Shortage of apparatus and materials used to conduct experiments
T2	Physical Science	Learners' failure to interpret results from the experiments
T3	Biology	Lack of chemicals and apparatus
T4	Physical Science	Less chemicals, lack of equipments and practical / scientific skills
T5	Biology	Learners not exposed to practicals from lower grade, leaners' lack of scientific skills
T6	Physical Science	Many learners in classes, fear of experimenting, lack of learner participation
T7	Biology	Overcrowded classrooms, learners' lack of interest and discipline
T8	Physical Science	Too many learners for the available materials
T9	Biology	Lack of chemicals /apparatus/equipments, overcrowded classrooms, small laboratory space
T10	Physical Science	Unstocked laboratories, lack of chemicals, apparatus and too large classes
T11	Biology	Learners' lack of communication during practicals, lack of resources, lack of learners concentration

T12	Physical Science	Learners' lack of interest and observation skills
T13	Biology	Lack of apparatus and space

APPENDIX 19: How problems affected the teaching of practical works

Teacher	How problems affected the teaching of practical works
T1	Shortage of materials makes it difficult to conduct practicals because learners are required to do and observe.
T2	Some practical investigations are not done
T3	Learners will lack hands-on knowledge on most practicals
T4	When you demonstrate to a large number of learners those at the back wont be able to observe what the teacher is demonstrating
T5	More time is needed to repeat a simple experiment with different groups
T6	Learners tend to be mere spectator instead of being actors
T8	Learners are organised in very large groups and most of them will not have a chance to participate in the activities
T9	Most practicals are demonstrations and observations
T10	Without chemicals and apparatus we don't teach practicals. How do you test for acids without Litmus papers or universal indicator
T11	Difficult to carry out some practicals due to lack of resources
T12	It hampers and denies learners the logical scientific reasoning because they don't do the practicals
T13	Difficult to teach practicals to overcrowded classes in a single small laboratory. For example, three classes in one lab.
T14	High failure rate because learners are not exposed and don't have practical skills