An intervention on how using easily accessible resources to carry out hands-on practical activities in science influences science teachers' conceptual development and dispositions

A thesis submitted in fulfilment of the requirements for the degree

Of

MASTER OF EDUCATION (Cwk/Thesis)

(SCIENCE EDUCATION)

Of

RHODES UNIVERSITY

By

Eva Ndagwedha Asheela

Supervisor: Prof KM Ngcoza

Co-supervisor: Ms J Sewry

January 2017

DECLARATION OF ORIGINALITY

I, Eva Ndagwedha Asheela, declare that this thesis is my own original work and has not, in its entirety or in part, been submitted for a degree in any other university. Where use was made of the work of others, it has been duly acknowledged in the text.

Signature:  Date: 05 April 2017

ABSTRACT

The reform and transformation of education systems in terms of enhancing Science, Technology Engineering and Mathematics (STEM) education in the schooling systems is gaining momentum in different parts of the world. It is argued that there is a need to enhance science education, particularly in Africa, because science education is considered to be the main vehicle through which the greater objectives such as national development and improvement in the quality of life can be realised. Namibia as a country is no exception.

A key way through which science education can be enhanced is through carrying out practical activities during teaching and learning. Despite the crucial role that practical activities play in science subjects, it appears that they are not carried out in most of the Namibian science classrooms. It is against this background that this study explored an intervention on how easily accessible resources to carry out hands-on practical activities in science, influenced science teachers' conceptual development and dispositions towards the use of practical activities in science.

In this study, a mixed methods case study approach underpinned by an interpretive paradigm was adopted. The research was conducted with 21 in-service science teachers from schools in Namibia who were all on a two year part-time BEd (Honours) program delivered in Namibia by a South African university from the Eastern Cape. To generate data, document analysis, questionnaires, semi-structured interviews, an intervention in the form of workshops on practical activities, lesson observations, which were videotaped, as well as teacher reflections were used. Conceptual development, disposition and professional development served as the conceptual lenses. Vygotsky's sociocultural theory in conjunction with Shulman's pedagogical content knowledge (PCK) were the theoretical frameworks adopted in the study.

The findings showed that there was a general perception among the participants before the intervention that in order to carry out practical activities, well-equipped laboratories, conventional chemicals and equipment are needed. Some teachers had never used practical activities in their science classes with a range of constraints or hindrances provided as reasons.

The findings additionally showed that for teachers to use easily accessible resources to carry out practical activities in their science classrooms, they need the knowledge and exposure on how to use these resources. The findings thus showed that this professional development approach raised motivation, knowledge and the skills of the science teacher participants to include practical activities in their science lessons using easily accessible resources. A recommendation is that if teachers are given opportunities, through professional development platforms to engage in hands-on practical activities using easily accessible resources, they can be enabled and motivated to implement these in their science classrooms.

DEDICATION

This thesis is dedicated to the following people:

My late mother, Ester Nauke Kapiya

My dear husband, Tuyoleni Ndeyanai

Our first-born son, Evans Landuleni-Omwene Tangi Ndeyanai (Dr Oti)

ACKNOWLEDGEMENTS

First and foremost, I would like to thank the almighty God for giving me the stamina to endure the pressure throughout this journey. It was a long journey but I made it through because of your mercy and grace.

Secondly, I wish to acknowledge my indebtedness to my supervisor, Professor Kenneth Mlungisi Ngcoza for his continuous and invaluable support and inspiration throughout this journey. You have been very encouraging and you always have your students' best interests at heart. Your availability and promptness in giving positive and constructive feedback on my writing have been amazingly excellent and have not gone unnoticed. Keep up the good work Professor Ken!

In the same vein, I would also like to extend my sincere appreciation to my co-supervisor, Mrs. Joyce Sewry for reading through my chapters and providing constructive feedback, as well as for the Kitchen Chemistry and Pollutant's Tale workshops which she presented to us in Grahamstown in August 2015.

I would also like to thank Mr Richard Grant for his workshops on using easily accessible resources to conduct practical activities in the science class which he presented to us in August 2015.

To Mr Robert Kraft, I would like to thank you for reading through my work and providing constructive feedback throughout my research journey.

To Ms Judy Cornwell, I thank you for your critical eye in editing my thesis.

I would also like to register my profound gratitude to my late mother, Ester, for enlightening me about the importance of education and for the discipline, morals and values she instilled in me from a very tender age. I am who I am today because of her flawless upbringing. May your beautiful soul continue to rest in eternal peace. Your legacy lives on and I am sure you are looking down and smiling!

To my husband, best friend and better half, Tuyoleni, thank you for being a wonderful companion. I embarked on this journey as a newly wedded wife but you have been very caring and supportive. More so, you executed your duties as head of family with distinction. May God bless you!

To our first born son and my namesake, Evans. As a first born, you deserved to get the lion's share of attention from me from day one. However, you were often neglected due to the demands of my research. Thanks for having been brave and understanding *sheeli*.

To my research participants, I'm tempted to mention your names here but I'm unable to reveal your identity due to ethical considerations. Thank you so much for being so supportive and understanding. Without your involvement, this project would not have been possible.

We are who we are because of others. This journey was only possible because of the wonderful support I received from my family, friends, classmates and colleagues. Thank you each and every one in your respective capacities for, in your own unique ways, making a mark in my research journey. Your support is highly valued, appreciated and acknowledged!

TABLE OF CONTENTS

LIST OF ABBREVIATIONS AND/OR ACRONYMS

T1-T21: Teachers 1 to 21 (M, male; F, female) (questionnaire responses)

IT1F: Interview with Teachers 1 (female)

IT2M: Interview with Teacher 2 (male)

IT3F: Interview with Teacher 3 (female)

ITC: Interview with Teacher Mrs Confidence

ITMP: Interview with Teacher Madam Physics

OB1/2/3: Observations 1/2/3 during the workshops

RT1-21: Reflections for Teachers 1-21

TCO: Teacher Confidence Observation

TMPO: Teacher Madam Physics Observation

L: One learner

LL: Two learners

LLL: Group of learners

HL1-36: Hope Secondary School Learners 1-36 Reflections

ML1-34: Millenium Secondary School Learners 1-34 Reflections

IKS: Indigenous Knowledge systems

LCE: Learner centred education

LTSM: Learning and teaching support material

MBEC: Ministry of Basic Education and Culture

MoE: Ministry of Education

NCBE: National Curriculum for Basic Education

NIED: National Institute for Educational Development

NSHE: Natural Science and Health Education

NSSCO/H: Namibia Senior Secondary Certificate Ordinary level/Higher level

PCK: Pedagogical Content Knowledge

SMK: Subject Matter Knowledge

TIMSS: Trends in International Mathematics and Science Study T1: Teacher 1 T2: Teacher 2

QUAL- Qualitative

quan- Quantitative

WS: Western Science

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1: SITUATING THE STUDY

1.1 Introduction

The main goal of my study was to explore how an intervention based on using easily accessible resources to carry out hands-on practical activities in science, influenced science teachers' conceptual development and dispositions towards the use of practical activities in science. In this chapter, the context is described. A summary of the research goal, objectives and questions follows and the conceptual and theoretical frameworks of the study are highlighted. The data gathering techniques are described followed by the definition of key concepts, the significance of my study and the thesis outline. The chapter ends with some concluding remarks.

1.2 Background to the study

According to Neuman (2011), a social context plays a significant role in research because it helps the reader to fully understand the research findings. This is why in this section, the international and regional contexts as well as the Namibian context are described in order to set the scene of the research.

1.2.1 The international and regional contexts

The reform and transformation of education systems in terms of enhancing Science, Technology Engineering and Mathematics (STEM) education in the schooling systems is gaining momentum in different parts of the world (Corlu, Caprano, & Caprano, 2014; Curriculum Development Council, 2015; Ostler, 2012).

Students in the United States (US) perform relatively poorly in international studies (e.g. Trends in Mathematics and Science Study (TIMSS), and the Programme for International Student Assessment (PISA) (National Research Council, 2011; Ostler, 2012). It is revealed that roughly 75% of eighth graders in the US are not sufficiently proficient in mathematics and science when they complete the eighth grade (National Research Council, 2011). Educational research further revealed that only 10% of the US eighth graders met the TIMSS target as compared to their Singapore and China counterparts who scored 32% and 25% respectively (ibid). It was thus evident that there is a need to strengthen STEM education in various parts of the world.

Although learners in Hong Kong perform well in science, technology and mathematics, there is the perception that they might be focusing only on the theoretical aspects of disciplines studies and are not participating in hands-on activities in schools (Curriculum Development Council, 2015). Yet, there is a need to strengthen the ability of students to integrate, connect and apply the subject content knowledge to real life situations through solving everyday life problems with practical solutions and innovative designs. This can be achieved through strengthening the practical aspects of STEM education (ibid). Corlu, et al. (2014); Erdogan and Stuessy (2015) as well as Howes, Kaneva, Swanson and Williams (2013) cement the idea by emphasising that STEM education should be strengthened.

In Turkey, the introduction of STEM education necessitated the professional development of in-service teachers with the emphasis on content and pedagogy (Corlu, et al., 2014). In order for STEM education to be implemented successfully, there is a need to capacitate teachers to cope with the changes introduced by the curriculum reform. This is in line with the ideas of Ostler (2012) who suggests that careful preparation of STEM teachers is considered essential to enable them to help secondary students develop the ability to specialise in STEM content at collegial level. This needs to be done via a learner-centred approach. These points resonate with the ideas of the Curriculum Development Council (2015).

Howes, et al. (2013), based on their study conducted in the United Kingdom, recommend that STEM education requires an in-depth understanding of concepts, the intellectual challenge as well as good dispositions and attitudes towards mathematics and science. They add that to achieve this requires improvement in teaching and learning, professional (lifelong) learning of teaching and of teachers and a learner centred curriculum which engages all students.

In the South African context, the TIMSS of 1995 and 1999 national assessment studies revealed findings which are similar to the findings of the US referred to earlier. It was found that learners' performance was very poor in comparison with other learners from other countries (Howie, 2004).

There is thus a need to enhance science education, particularly in Africa according to Brock-Utne (2001), because science education is considered to be the main vehicle through which the greater objectives such as national development and improvement in the quality of life can be realised. Namibia as a country is no exception.

1.2.2 The Namibian context

Central to the Namibian National Curriculum of Basic Education (NCBE) is the Learner Centred Education (LCE) pedagogy (Namibia. Ministry of Education and Culture [MEC], 1993; Namibia. Ministry of Education [MoE], NCBE, 2010). This approach was adopted upon independence in 1990 as part of the education reform and is in line with Namibia's four goals of basic education, namely, *equity, quality, access* and *democracy*. In order to meet the reform goals, the policy framework, "Toward Education for All", prescribed that, "our teaching methods must allow for the **active involvement and participation of learners**" [my emphasis] in the learning process (Namibia. MEC, 1993, p. 119).

Despite the ideals of the NCBE, however, it was found that there is a disjuncture between teachers' understanding of LCE on one hand and their practice on the other hand (Nyambe, 2008). Nyambe's study revealed that the constraining factors which hindered the successful implementation of LCE were among others: teachers' self-doubt and lack of professional competence, **lack of professional support** [my emphasis] and inadequate academic background. In a follow up study, Nyambe and Wilmot (2012) attempted to find out how teacher educators (lecturers) at teacher training colleges interpret and practice LCE. It emerged from their findings that the teacher educators (lecturers) also experienced a mismatch between their understanding of LCE at the level of description and their practice of LCE at the level of implementation. The findings of Nyambe (2008) and Nyambe and Wilmot (2012) agree with the findings of Enghono (2013), Kasanda, Lubben, Gaoseb, Kandjeo-Marenga, Kapenda and Campbell (2005), Mbangula (2010), and Mukwambo (2012) who all articulated corresponding views based on studies conducted in Namibian classrooms.

1.2.2.1 The Namibian National Curriculum for Basic Education

The Namibian National Curriculum for Basic Education (NCBE) (2010) emphasises a learner-centered approach for teaching, learning and assessment. The NCBE stipulates that learners should use the immediate environment, everyday items and waste materials to investigate phenomena using a scientific approach. It also points out that it may be necessary, and sometimes preferable, for teachers to improvise learning and teaching support materials (LTSMs) from easily available and inexpensive objects in the immediate environment, such as sticks, strings, bottle tops, cardboard, and so forth provided that they are safe and hygienic. The curriculum is thus in favour of using easily accessible resources from the local environment and context of the learners during the teaching and learning repertoires.

The subject policy guide for Physical Science grades 8-12 (which is similar to Life Science grade 8-10 and Biology grade 11-12) stipulates that teachers in Physical Science should be creative and innovative in order to produce their own teaching and learning materials which are linked to practice (Namibia. MoE, Subject Policy, 2008). It further points out that in the JSC and NSSC syllabi, the practical activities, approaches or demonstrations required for each topic are included in the syllabus. It states that these suggested practical activities are considered basic, and all learners should be exposed to them as a minimum requirement. It also highlights that each learner must acquire practical skills, attitudes and knowledge.

In the Namibian context, there is emphasis in the subject policy that in a country where many learners may not have a scientific background that will help them develop the skill and knowledge of the scientific world, it must be seen as a seriously lost opportunity if this experience is not provided in the school environment. From my analysis, the subject policy is well articulated in terms of promoting practical activities and encouraging teachers to use materials from their local environment to carry our practical activities. However, in terms of how to carry out the practical activities, it is not explicitly stated.

From the Junior Secondary Certificate (JSC) and Namibia Senior Secondary Certificate Ordinary/Higher (NSSCO/H) Physical Science syllabuses (Namibia. MoE, Syllabuses, 2010), as indicated in the subject policy guide, the suggested practical activities are stipulated in at the end of each topic. The syllabi also emphasise using resources from the local environment by stating that teachers are therefore urged where appropriate to use local examples to illustrate scientific issues, concepts and processes. From my analysis, although emphasis is placed on local context and use of local materials, there is hardly any mention of actual examples in the suggested practical activities.

For instance, on the test for oxygen, the syllabus states that oxygen should be prepared using potassium permanganate or from the reaction of manganese oxide and peroxide. In this case, a teacher who does not know that one can also use bleach or yeast and peroxide which are easily obtainable and affordable from local shops would not be able to carry out this activity if the materials prescribed in the syllabus are not available in the schools as is often the case.

Another example deals with carbon dioxide and hydrogen gases for instance. The syllabus prescribes preparation of carbon dioxide from metal carbonates and acids. It also prescribes using a metal and an acid to prepare hydrogen. Should a teacher not know that they can use, for example, egg shells, pieces of chalk, sea shells (as materials which are rich in calcium carbonate) with acids, or fermentation of traditionally brewed beverages, or exhaled air, or vinegar and baking soda, or capturing gas from a soft drink such as Coca-Cola, the teacher will not be able to improvise as encouraged by the curriculum documents. Similarly, if a teacher does not know that they can use aluminium foil (which can be obtained from waste material such as pie holders or used foil) together with caustic soda (which is affordable in local supermarkets), the teacher may not be able to improvise since these substitutes are not suggested in the syllabus.

Another example is on practical suggestions about diffusion, which mentions the use of potassium permanganate crystals, copper sulphate, nitrogen gas, and ammonia solution as examples. Although there are other easier alternatives such as using tea bags and coffee in hot and cold water, air fresheners and aromas to put the concept across, teachers who are not aware of these alternatives would not be able to do the experiments since the syllabus does not stipulate them. In the case of sublimation, for example, the prescribed example in the syllabus is the use of dry ice and iodine. Yet, we have naphthalene which is easily obtainable from supermarkets and which could be used as an alternative.

TABLE 1: EXTRACTS FROM CURRICULUM DOCUMENTS

Themes	Evidence from curriculum documents
Prior everyday knowledge (Prior knowledge, Indigenous/Traditional knowledge)	- *The point of departure to teaching and learning is always what the learner knows and can do (NCBE, 2010, p. 4)* - *The learner brings to school knowledge and social experience from home, community and environment. This knowledge and experience is a potential that should be utilised and drawn into teaching and learning (Physical Science subject policy guide, p. 7)*
Use of easily accessible resources	- *Natural Sciences teaching, for example, provides many opportunities for learners to use the immediate environment, everyday situations, everyday items and waste materials to investigate phenomena using a scientific approach (NCBE,2010, p. 26)* - *It may be necessary and sometimes preferable for teachers to improvise teaching and learning materials from easily available and inexpensive objects in the immediate environment such as sticks, string, bottle tops, cardboard, etc. provided that they are safe and hygienic(NCBE, 2010,p. 27).* - *Teachers in Physical Science should be creative and innovative to produce their own teaching and learning materials linked to practice (Physical Science subject policy guide, 2010, p. 4)* - *The learning content in this syllabus is based on the Namibian context, although the themes and topics are on a variety of scales to meet international standards. Teachers are therefore urged where appropriate to use local examples to illustrate scientific issues, concepts and processes (JSC Physical Science syllabus,2010, p. 3).*
Practical activities	- *Through learner centred education learners are actively involved. In the JSC and NSSC syllabuses the practical activities, approaches or demonstrations required for each topic are included in the syllabus. These are considered basic, and all learners should be exposed to them as a minimum requirement. (Physical Science subject policy guide, p. 4)* - *Each learner must acquire practical skills, attitudes and knowledge. In a country where many learners may not have a scientific background that will help them develop the skill and knowledge of the scientific world, it must be seen as a serious opportunity lost if this experience is not* - *provided in the school environment. (Physical Science subject policy guide,2010, p. 4)*

In general, the NCBE, (2010) subject policy document and syllabi put an emphasis on improvisation and use of materials and resources from within the local environment. However, most of the prescribed chemicals and equipment under suggested practical activities in the syllabi stress mainly conventional materials which do not help a teacher who may not be aware that some resources in their local environments (contexts) might be useful, they may not be in position to identify these materials and make use of them in the classroom.

1.2.2.2 Examiners' reports for JSC and NSSCO/H Physical Science

At the end of grade 10, Namibian learners sit for the Junior Secondary Certificate (JSC) external examination. Similarly, at the end of grade 12, Namibian learners sit for the Namibian Senior Secondary Certificate Ordinary and Higher level (NSSCO/NSSCH) external examinations. In all these external examinations, learners are expected to demonstrate competence in responding to practical related questions. More so, in the NSSCO and NSSCH external examinations, in particular, paper 3, learners sit for an alternative to practical examinations question paper (NSSCO) and a practical test in which they carry our practical activities individually as an examination (NSSCH). Exposure to practical activities from grade 8 level is aimed at laying a foundation to preparing learners for the JSC and eventually NSSCO/NSSCH.

Despite the crucial role that practical activities play in the science subjects, it appears that they are not carried out adequately in the Namibian classrooms. This emerged from examiners' reports for the JSC, NSSCO and NSSCH external examinations. It was revealed in the examiners' reports that learners do not show comprehension of concepts and at times, the knowledge demonstrated is rather superficial (Namibia. MOE, 2011 report). It was thus suggested that learners should be exposed to sufficient practical activities **drawing on examples from everyday life** [my emphasis] right from grade 8 to grade 12 to bring about relevance (ibid).

In general, examiners' reports revealed that learners are not sufficiently prepared in terms of practical activities. The following are examples of extracts from examiners' reports.

TABLE 2: EXTRACTS FROM EXAMINERS' REPORTS, (2011-2015)

• *'learners should be exposed more to practicals and the discussions thereof'* (Namibia, MoE, 2011,p.238, report). • *'learners should be made aware of the chemistry practical notes at the end of the paper, and be shown how to use them'* (Namibia, MoE, 2012, p.374, report). • *'an impression was given that hardness in water was superficially taught'*(Namibia, MoE, 2013, p.249, report). • *'learners should be exposed to more practical work even though they do an alternative to practical work'*(Namibia, MoE, 2013, p.400, report). • *'It is mandatory for success that candidates do practical exercises throughout the junior secondary phase as well as in Grade 11 and the Grade 12 year'* *'teachers should draw on examples from everyday life to do practical activities'* *'teachers must expose learners to more hands-on practicals'* (Namibia, MoE, 2014, p.399, report). • *learners could not identify the correct apparatus',* (Namibia, MoE, 2013, p.374, report).

In general, it emerged from the examiners' reports that learners are not being sufficiently prepared in terms of practical activities as demonstrated by the way they respond to questions during the external examinations. This was demonstrated by repeated suggestions which featured almost every year in examiners' reports such as 'learners *should be exposed more to practicals and the discussions thereof'; 'an impression was given that hardness in water was superficially taught'; learners should be exposed to more practical work even though they do an alternative to practical work'* (Namibia, MoE, 2011, p. 238; 2013, p.249 reports).

The examiners' reports in general, as part of positive suggestions to teachers, recommend that learners be prepared in terms of practical activities throughout grades 8 to 12 by stating that '*It is mandatory for success that candidates do practical exercises throughout the junior secondary phase as well as in grade 11 and the grade 12 year'* (Namibia, MoE, 2014, p.399, report). What I found interesting is when the examiners' reports emphasise the use of hands-on practical activities and drawing on everyday examples by stating that '*teachers must expose learners to more hands-on practicals'; 'teachers should draw on examples from everyday life to do practical activities'*(Namibia, MoE, 2014, p.399, report). These examiners' comments triggered my interest to engage in this study which explored the use of easily accessible resources to do hands-on practical activities

1.2.3 Personal experience as a teacher

From my own experience as a teacher, I realised that it is difficult to carry out practical activities in the schools. Since I started teaching in under-resourced rural schools in 2007, it has always been difficult to acquire the chemicals and equipment needed to carry out practical activities as prescribed in the syllabi. When I attended professional development workshops at circuit, regional and national levels respectively, other teachers expressed similar concerns in this regard. Since I was involved as a marker for NSSCO paper 3 (alternative to practical) in the external examinations, I too noticed that the way most of the learners responded to questions gave the impression that they had not been sufficiently prepared in terms of practical activities.

When I joined Rhodes University for the BEd (Honours) (2014) and MEd (2015) programs respectively, I was exposed to the use of easily accessible resources to carry out practical activities in science classrooms through the themes of prior knowledge, indigenous knowledge and practical work. For instance, in 2014 in Namibia, a workshop was carried out during the BEd (Honours) contact session to demonstrate the preparation of an Oshiwambo traditionally brewed beverage called *Oshikundu* as a strategy to show the process of fermentation and formation of carbon dioxide (Asheela, Ngcoza, & Enghono, 2015; Nicodemus & Ngcoza, 2015). Similarly, when we attended the research design course session in Grahamstown in August 2015, we had exposure to the use of constructing classroom science tools and conducting experiments using easily accessible resources in the form of workshops. These were presented by Mrs. Joyce Sewry and Mr. Richard Grant in 2015 respectively. We also had experience of using an indigenous practice of making an *isiXhosa* traditionally brewed beverage called *Umqombothi* (which is similar to the preparation of *Oshikundu*) by *Mama* Joyce Nolingo which also involves the process of fermentation and formation of carbon dioxide. All these experiences motivated me to do research on the use of easily accessible resources in hands-on practical activities that would influence science teachers' conceptual development and dispositions towards practical activities in science.

Some earlier Namibian case studies have explored individual teacher's use of easily accessible resources as a means of conducting practical activities in science classrooms (e.g. Kambeyo, 2012; Nicodemus & Ngcoza, 2015; Shifafure, 2014; Uushona, 2012). A similar study was conducted by Kuhlane (2011) in South Africa. It emerged from these studies that sense making, conceptual understanding and learner engagement were enhanced if these activities are properly implemented. Learners were able to make links between the subject matter taught in the classroom and the materials available in their local contexts. However, the focus of these earlier studies was not explicitly on the issue of the use of practical activities and not on the attitudes of teachers towards the use of easily accessible materials in the science classrooms. My study thus sought to close that gap by exploring how an intervention using easily accessible resources to carry out hands-on practical activities influenced science teachers' conceptual development and disposition towards use of practical activities in science.

1.3 Statement of the problem

The constitution of the Republic of Namibia stipulates in article 19 that "every person shall be entitled to enjoy, practise, maintain and promote any culture, language, tradition or religion" Namibia (1998, p. 21). Using easily accessible resources to carry out hands-on practical activities in the science classroom is one way whereby learners can enjoy their cultures and traditions, as the resources used are from the learners' local environments.

Conducting practical activities in the science classroom has proven to be a challenge over the years as reflected in examiners' reports (Namibia. Ministry of Education [MoE], 2010-2014). Examiners' reports revealed that the learners' knowledge as demonstrated in responses to examination questions appear superficial (MoE, 2010-2014).

The practical activities which are suggested in the syllabuses for Physical Science 8-12, Life Science 8-10 and Biology 11-12 (Namibia, MoE, 2010) are based mainly on conventional laboratory-based chemicals and apparatus and there is little mention of the examples of using locally available materials/equipment to conduct practical activities which could potentially inform teachers on alternative resources that could be used. Most schools in Namibia are not well-equipped with the prescribed equipment to carry out practical activities and in such cases, teachers resort to teaching theory without carrying out practical activities or demonstrations with their learners. This may result in rote learning and regurgitation of facts at the expense of learning for understanding.

The NCBE (2010) emphasises local context and content. A gap therefore exists between the broad intentions of the curriculum involving use of easily accessible resources (local context) on the one hand and the implementation of these intentions in the classroom on the other hand. That gap could be narrowed by the findings of research which focuses on using locally available materials to carry out practical activities in science classrooms. My research is therefore based on the premise that, small scale research on using easily accessible resources to carry out practical activities in the science classrooms may lead to greater possibilities of useful classroom inclusion. It is adapting this kind of research that teachers could exercise local relevance by bringing home-grown materials into the classroom to add potential value and this is highlighted in the next section.

1.4 Significance of my study

This research was a qualitative case study that investigated the dispositions of teachers towards the use of easily accessible resources during practical activities;

- The study may thus inform practising science teachers about the use of easily accessible resources to conduct practical activities in science classrooms. It is hoped that through exposure to practical activities, teachers may become empowered to incorporate the use of easily accessible resources in their science classrooms;
- Curriculum developers may gain some understanding of the issues of incorporating indigenous knowledge and everyday materials from the local environment in science classrooms;
- Textbook authors and developers of learning and teaching support materials (LTSMs) may find it useful to consider incorporating the use of easily accessible resources in textbooks and LTSMs in order to provide support to learners and teachers;
- As I am now involved in professional development at the National Institute for Educational Development (NIED), the findings of this study may assist me in understanding the factors that influence science teachers' experiences and dispositions towards practical activities. This could make a difference when conducting professional development workshops; and

- The study is an exercise in teacher development which may cast light on the merits of this approach to developing the classroom practice of teachers.

1.5 Research goal, objectives and questions

In the next sub-sections, my research goal, objectives, question and sub-questions are stated.

1.5.1 Research goal

The main goal of my study was to explore how an intervention on using easily accessible resources to carry out hands-on practical activities in science influences science teachers' conceptual development and dispositions towards use of practical activities in science.

1.5.2 Research objectives

The objectives of my study are:

1. To explore the experiences of science teachers regarding the use of hands-on practical activities in science classrooms;
2. To identify the factors which influence science teachers' experiences regarding the use of hands-on practical activities in science classrooms;
3. To explore how an intervention in the form of a workshop on the use of easily accessible resources to carry out practical activities in the science classrooms influences science teachers' conceptual development and their dispositions towards hands-on practical activities in science; and
4. To explore the possibilities of this approach (intervention in the form of a workshop) for teachers' Continuous Professional Development (CPD) in the Namibian context.

1.5.3 Main research question

How does an intervention using easily accessible resources to carry out hands-on practical activities in science influence science teachers' conceptual development and dispositions towards practical activities in science?

1.5.4 Sub-questions

Phase 1: Before the intervention:

1. What are science teachers' experiences of doing hands-on practical activities in their science classrooms?
2. What factors influence science teachers' experiences of doing hands-on practical activities in their science classrooms?

Phase 2: Intervention in the form of workshops for one week

3. How does an intervention (in the form of a workshop) on the use of easily accessible resources to carry out hands-on practical activities in the science classroom influence science teachers' conceptual development and dispositions towards practical activities in science?

Phase 3: Teaching using easily accessible resources to carry out practical activities

4. What factors enable or constrain science teachers when mediating learning using easily accessible resources to carry out hands-on practical activities in their science classrooms?

1.6 Conceptual framework

This study is informed by the concepts of disposition and professional development. In the context of my study, disposition refers to the attitudes, the tendency to act in a certain way or the tendency to develop positive characteristics. Professional development has to do with keeping abreast with the latest trends in one's work.

1.7 Theoretical framework

In addition to the conceptual framework, this study is also informed by two theoretical frameworks, namely, Vygotsky's (1978) sociocultural theory and Shulman's (1986, 1987) theory on pedagogical content knowledge (PCK). According to Vygotsky (1978), meaningful learning is enhanced when human beings learn through socially interacting with materials from their cultures based on the understanding that human intelligence originates in the society or culture. Similarly, Shulman (1986, 1987) supports that in order to foster understanding, a teacher needs to present the subject matter knowledge in a way that ensures epistemological access, drawing on examples from learners' contexts to facilitate learning to enhance understanding of the subject content and basic scientific terminology.

1.8 Data gathering techniques

- Documents analysis;
- Questionnaires;
- Workshops;
- Semi-structured interviews; and
- Observations, videotaped lessons and reflections.

1.9 Definitions of key concepts

1.9.1 Intervention: a deliberate process by which change is introduced into people's thoughts, feelings and behaviours.

1.9.2 Sociocultural theory: a theory which states that learning and sense/meaning making originates in the interactions between individuals or as individuals operate in social contexts engaging with cultural products which are made available to them in their contexts.

1.9.3 Subject matter knowledge (SMK): a concept which describes the way in which information relating to specific topics is possessed.

1.9.4 Pedagogical content knowledge (PCK): a concept which describes the way in which teachers present and formulate their subject content in order to make it easily comprehensible by their learners.

1.9.5 Prior (everyday) knowledge: the information that learners bring to the classroom which can be concepts learned in earlier grades or information gained from their homes/ cultures/ communities.

1.9.6 Practical activities: learning experiences which are designed to, through action, forge a link between the observations and the theories/ideas of science.

1.9.7 Disposition: this has to do with attitudes, the tendency to act in a certain way or the tendency to develop positive characteristics.

1.9.8 Conceptual development: the ability to develop scientific understanding of fundamental concepts based on given contexts.

1.9.9 Easily accessible resources: materials that are easily available within a particular context, materials which can be obtained from the local environment or bought from local supermarkets.

1.10 Thesis outline

The study was conducted with the BEd (Honours) Science Elective students of a certain university in South Africa, Eastern Cape Province (2014-2015). The entire class of 21 students participated in phases 1 and 2. For phase 3, the study continued with two teachers, one from a secondary school in Okahandja, Otjozondjupa region in central Namibia and the other from a secondary school in Oshikoto region, northern Namibia. The thesis consists of seven chapters and the following is an overview of the chapters.

Chapter 1

The first chapter of the study explains the context and background of the study. This includes the purpose, outline and structure of the study. A discussion of the background of the research is presented. The reasons for carrying out the study are outlined. The statement of the problem, significance of my study, research, goal, objectives and questions are specified and the conceptual and theoretical frameworks are introduced. The data gathering techniques are described and the key concepts are defined.

Chapter 2

The second chapter of the study looks at the relevant literature, situating the study in context with similar studies to see what has already been researched. It provides an overview of the literature relating to the expectations of the Namibian curriculum with regard to learner-centred education, practical activities, prior everyday knowledge and the use of easily accessible resources. It also looks at the concepts of conceptual development, disposition, professional development and reflections. In addition, an account of the theoretical framework utilised in the research is described.

Chapter 3

This chapter provides clarity in terms of the mixed methods research methodology adopted in the study. The data gathering techniques and the rationale behind their use are portrayed. Thus, it answers the question why a mixed methods research methodology was adopted. Further, the reasons behind the use of document analysis, interviews and lesson observations are explained. The use of the purposive and convenience (*see* 3.4.3) sampling techniques are discussed. Lastly, an overview of the data analysis procedures is presented.

Chapter 4

This chapter provides a narrative account of the data generated through phase 1 (before the intervention). The chapter begins with a profile of the of the research participants, that is, their qualifications and teaching experience. The chapter focuses mainly on the quantitative data gathered. This is aimed at answering research sub-questions 1 and 2 (see Section 1.5.4). In this chapter, the data gathered in phase 1 are also analysed and discussed.

Chapter 5

This chapter summarises the results of the data collection of phase 2 (the intervention in the form of a workshop). The presentation is from the perspective of the research participants and several direct quotes are included. The highlights of the interviews, observations and reflections are sketched. This chapter is aimed at answering research sub-questions 3 (see Section 1.5.4). In this chapter, the data gathered in phase 2 are also analysed and discussed.

Chapter 6

This chapter summarises the results of the data collection of phase 3 (classroom observations on two teachers' teaching). The chapter begins with the profiles of the two teachers, their qualifications and teaching experience. This chapter aims at answering research sub-question 5 (see section 1.5.4). The data from the classroom observations and interviews conducted in phase 3 are also analysed and discussed.

Chapter 7

This chapter sums up the main findings. These comprise:

- Implications of the research outcomes;
- Suggestions for Physical Science teachers;
- Limitations of the study, and suggestions for further research;
- Lessons learnt from the study;
- Recommendations; and
- Personal reflections.

1.11 Concluding remarks

In this chapter the context of the study, the research goal, objectives and questions, definition of concepts and the thesis outline were discussed as a means of setting the scene for the reader. That is, this was intended to help the reader navigate through the thesis with ease.

In the next chapter, the literature relevant to the study is reviewed.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The main goal of my study was to explore how an intervention using easily accessible resources to carry out hands-on practical activities in science influences science teachers' conceptual development and dispositions towards the use of practical activities in science

In this chapter, I discuss the expectations of the Namibian Curriculum of Basic Education (NCBE) and other policy documents in terms of practical work, prior everyday knowledge and the use of easily accessible resources.

Thereafter, I discuss the various conceptual and theoretical lenses that I have adopted for my study. In this regard, I look at conceptual development, professional development and disposition as my conceptual lenses. I also adopted Vygotsky's sociocultural theory and Shulman's theory on Pedagogical Content Knowledge (PCK) respectively as my theoretical frameworks.

2.2 The Namibian National Curriculum of Basic Education (NCBE)

The NCBE is the official policy for teaching, learning and assessment in Namibia and it gives direction in terms of how to plan, organise and implement teaching and learning (MoE, NCBE, 2010). The purpose of the NCBE is to provide a framework which ensures uniformity in curriculum delivery in schools throughout the country. It also provides the structure for developing syllabuses, learning materials and textbooks to be used in various subjects and areas of learning (ibid). Of relevance to this study, the NCBE emphasises the inclusion of prior everyday knowledge, the use of practical activities and the use of easily accessible resources in teaching and learning. These will be discussed individually in the following sections.

2.2.1 Prior everyday knowledge as reflected in the Namibian curriculum

The NCBE stipulates that the fundamental structure of the learning process at all levels is to use the learners' existing knowledge and ideas to bring in new knowledge and to facilitate and direct them in transforming their prior knowledge into new knowledge (MoE, NCBE, 2010). This is based on the notion that learning begins with the interests of learners and their experiences (MEC, 1993). These references are based on the premise that learners do not come to school as empty vessels but they possess knowledge which is accumulated from their everyday life experiences which can be taken advantage of and capitalised on during the learning process. In the context of this study, prior everyday knowledge entails a combination of prior knowledge and traditional/indigenous knowledge.

2.2.1.1 Prior knowledge

In line with the NCBE prescriptions, Roschelle (1995) posits that research has shown that a learner's prior knowledge often confounds an educator's best efforts to deliver ideas accurately and that learning proceeds predominantly from prior knowledge. He further states that to make the best of a new experience, educators need to understand just how prior knowledge affects learning and that learners construct concepts from prior knowledge.

Following a similar line of thought, Johnstone (2010) affirms that chemistry should be presented in a way that capitalises on what learners are familiar with and which is already anchored in their long term memory. This concurs with the findings of a study conducted in South Africa on making use of everyday knowledge in the science classroom, in which Stears, Malcolm and Kowlas (2003) observed that building learners' prior knowledge into the science curriculum is fruitful and that learners relate strongly to content that deals with the facts of their lives. They add that the greater the degree of connectedness with the learning material, the deeper the levels of engagement of learners with each other and with the teacher.

Similarly, the use of everyday contexts in science classroom teaching has been promoted in Africa for purposes of curriculum relevance (Kasanda, et al., 2005). In their research conducted in Namibia on the role of everyday contexts in learner centred teaching, it was found that bringing learners' experiences into the classroom proved a successful technique.

Kuhlane (2011) too conducted her research in Grahamstown, Eastern Cape Province, South Africa. It emerged from Kuhlane's study that meaningful learning took place as shown by the engagement of learners in the mediated learning process. Enghono (2013) articulates corresponding views based on her research conducted in Namibia on prior knowledge with in-service science teachers where it emerged that meaningful learning took place as a result of the engagement of students in the mediated learning process.

Despite the perceived advantages of inclusion of prior knowledge, some teachers do not always consider prior knowledge in their lessons. For instance, in a study conducted in Nigeria by Oloruntegbe and Ikpe (2011), it was found that there were a substantial number of chemistry students who could not establish a bridge between school science and relevant phenomena in their homes such as evaporation, boiling, condensation, filtration, despite daily exposure to both. As a result, the students perceived a so-called gap between household chores and school chemistry, a situation which makes students perceive the subject as fragmented and not making sense. They add that teachers are not consciously using phenomena from students' daily life experiences in presenting materials in the chemistry classrooms (ibid). The findings of Oloruntegbe and Ikpe (2011) resonate with those of Kasanda, et al. (2005), based on their study in Namibian classrooms.

Roschelle (1995) cautions that neglect of prior knowledge can result in the audience learning something opposed to the educator's intentions, no matter how well those intentions are executed. Despite the benefits of inclusion of prior everyday knowledge, there are also challenges associated with prior knowledge. Roschelle (1995) warns that prior knowledge is not always advantageous as sometimes the same element of prior knowledge can provide an incorrect alternative to a theory. He termed these as "preconceptions, alternative conceptions, naive conceptions, misconceptions" (p. 9). In support, Taylor (1999) also cautions that when using every day knowledge, care should be taken not to foreground it at the expense of conceptual knowledge and in-depth study of concepts. Let us now turn our attention to traditional knowledge or indigenous knowledge.

2.2.1.2 Traditional knowledge or indigenous knowledge (IK)

A large body of literature calls for the inclusion of IK in science curricula (e.g. Le Grange, 2007; Ogunniyi & Ogawa, 2008; Shizha, 2007). Inclusion of IK in curricula, in particular science curricula, is perceived to be beneficial.

To this end, Mukwambo, Ngcoza and Chikunda (2014) encourage the promotion of the inclusion of IK in science curricula, particularly in Africa, stating that it "promotes teaching and learning scenarios in which both teachers and learners engage in knowledge construction (a LCE exercise) in the full diversity of cultural, racial, ethnic and religious practices of all people so as to bring about common understanding" (p. 72). They further emphasise that since there is a dialectical relationship between IK and western science (WS), that is, IK is embedded in WS, it can be used as prior knowledge to reduce the challenges associated with WS so that the two worldviews complement each other (Roschelle, 1995).

Kibirige and van Rooyen (2006) agree that science teaching is enriched when IK is used as indigenous prior knowledge in the classroom and can thus be used as a starting point to explore concepts associated with WS. Breidlid (2009) and Shizha (2007) postulate corresponding views emphasising that IK and WS should complement one another rather than be seen as competing. Cronje, de Beer and Ankiewicz (2015) are also in favour of integration of indigenous knowledge in science classrooms.

In the same vein, O'Donoghue, Lotz-Sisitka, Asafo-Adjei, Kota and Hanisi (2007) indicate that indigenous knowledge systems can enhance learner centred education, using examples of *imifino,* the fermentation of *Umqombothi* and the preparation of *Amarewu*, in which learners are actively involved in the learning process, such as in gardening using indigenous plants. The emphasis of O'Donoghue, et al. (2007) is on involving the community in learning experiences, and this in itself promotes learner centred education. The findings of O'Donoghue, et al. are in agreement with the findings of Klein (2011) in the Namibian context.

Relating to this idea of incorporating IK, Le Grange (2007) states that it is important for science to be viewed as 'performance' rather that 'representation', that is, science needs to be viewed as doing, as a human and social activity which is situated (p. 589). If science is viewed as performance, then IK and WS are complementary and this in turn provides the basis for effective science education (ibid). In agreement, Hodson (2009) also contends that the notion of WS and IK should not be politicised but instead science should be taken as the harmonizing accumulation of knowledge about the natural environment.

Notwithstanding, Horsthemke and Schäfer (2007) and Hodson (2009) critique IK and caution that when incorporating IK, it should not be done in a way that it is taken on uncritically without proper scrutiny. Concurring, Mukwambo, et al. (2014) articulate corresponding views emphasising that

IK needs to be properly examined before it is used so that any contradictions could be exposed. They further warn that IK is deeply rooted in people's beliefs, some of which are entrenched in 'myths' that are hard to explain in a scientific sense. So, they advise that teachers need to have a deep understanding of WS in order to be able to incorporate IK effectively with WS. For instance, one possible terrain in which IK could be incorporated is during practical activities in science classrooms.

Practical activities are central in the science classroom. In the subsequent discussion, the expectations of the NCBE regarding practical work are elaborated on.

2.2.2 Practical activities in the Namibian curriculum

Carrying out practical activities, practical demonstrations and practical investigations are among the requirements of the natural sciences subjects' spectrum. According to the NCBE, understanding scientific processes, the nature of scientific knowledge and the ability to apply scientific thinking and skills is a requirement in the natural sciences (Namibia. MoE, NCBE, 2010). The curriculum further prescribes that there is a need to empower learners with the scientific knowledge, skills and attitudes to formulate hypotheses, to investigate, observe, make deductions and understand the physical world in a rational scientific way (ibid). In this regard, the syllabuses for Natural Science and Health Education (NSHE) grades 5-7, Physical Science grades 8-12, Life Science grades 8-10, Biology grades 11-12 and Agriculture grades 8-12 prescribe practical activities and demonstrations which all the learners should be exposed to as a minimum requirement at the end of each topic (Namibia, MoE, Syllabuses, 2010). The subject policy guides for Physical Science for grades 8-12, Life Science and Biology grades 8-12 and Agriculture grades 8-12 resonate with the NCBE and with the respective syllabuses (Namibia, MoE, 2008).

One of the assessment objectives which is tested across grades 5-12 in the natural sciences subjects' spectrum (NSHE, Physical Science, Life Science, Biology, Agriculture) deals with experimental and investigative skills and abilities (Assessment Objective C) (Namibia, MoE, Syllabuses, 2010). Practical skills are considered important especially in the Namibian context as stated in the JSC Physical Science syllabus. Namibia, like most African countries, is rich in natural resources and the exploration of these resources requires scientific knowledge and relevant skills

(Namibia. MoE, Subject Policy, 2008). Furthermore, it states that scientific skills are a prerequisite for a progressive national economy and a means of satisfying human needs (ibid). This is also in line with the Namibian vision, Vision 2030, which stipulates that, by the year 2030, Namibia should be "a prosperous and industrialised Namibia, developed by her human resources, enjoying peace, harmony and political stability" (Namibia. MoE, NCBE, 2010, p. 2).

In agreement with the recommendations of the NCBE, a large body of literature states that practical activities are fundamental to science teaching and learning (e.g. Abrahams & Millar, 2008; Jokiranta, 2014; Millar, 2010).

To this end, Gott and Duggan (1996) express that, when selected carefully with a clear purpose in mind, practical activities have a key role in the teaching of evidence. Concurring, Maselwa and Ngcoza (2003), state that practical activities encourage active participation, highlighting that it enables identification of key concepts, conceptual understanding, education quality and relevance and makes learners experience science first hand. When done well, learners find that practical activities are enjoyable, engage their learning at different levels and challenge them mentally compared to other teaching and learning approaches in science (Woodley, 2009; Abrahams & Millar, 2008). Effective practical activities enable learners to make links between theory and practice, ensuring that the students are able to apply their scientific understanding to the real world application of science (Millar, 2010; Woodley, 2009).

Hodson (1990) endorses that 'hands-on' practical activities are an enjoyable and effective form of learning. In a similar line of thought, Maselwa and Ngcoza (2003) state that practical activities should be 'hands-on', 'minds-on' and 'words-on'. Woodley (2009) agrees and advises that a good question to ask before conducting practical activities is "what do I expect the students to learn after doing this practical activity that they could not learn at all, or not so effectively when they were merely told what happens?" (p. 50). It is thus considered obligatory for science teachers to help the students see these connections between the theoretical ideas taught and the phenomena seen in practical activities (Jokiranta, 2014).

In spite of the perceived advantages, there are also challenges associated with practical activities. Pertaining to this, Hodson (1990) disputes the educational value of some practical work. He argues that some practical work as conducted in many schools is ill-conceived, confused and unproductive. He adds that practical activities in many schools provide little in terms of real educational value because teachers use practical activities thoughtlessly.

Responding to Hodson's (1990) concern, Maselwa and Ngcoza (2003) caution that teachers should not equate activity with learning and that practical activities should not be of a recipe/cookbook approach but suggest that the approach of predict-explain-explore-observe-explain (PEEOE) should be employed during practical activities.

Of relevance to my study is that Maselwa and Ngcoza (2003) are in favour of conducting practical activities using easily accessible resources and this is discussed in the subsequent section.

2.2.3 The use of easily accessible resources as reflected in the Namibian curriculum

The NCBE stresses that the community around the school can be an important support and resource, as well as a source of knowledge for learners to do research and project work (MoE, 2010). In this way, learner centred education (LCE) can incorporate the indigenous/local/everyday knowledge of learners from local communities into the lessons.

In response to the recommendations of the NCBE, a handful of Namibian scholars have embarked upon a journey to use easily accessible resources (e.g. Kambeyo, 2012; Klein, 2011; Shifafure, 2014; Uushona, 2012). For example, Klein (2011) worked on a school project called Traditional Life Skills Project (TLSP) in which learners and parents were involved in making handcrafted materials in school. Kambeyo (2012) made use of *Ombeke* (Sour plum), *Onkenkete* (Buffalo thorn fruit), *Oombu* (a sour-sweet fruit), *Ontantahe* (a local sour-sweet fruit), *Ooshe* (a local wild fruit known to be a delicacy for San people), *Oonkwiyu* (cluster figs), as easily accessible indigenous substances available in the learners' community to teach acids and bases. It emerged from his study that learners enjoyed making links to the materials available in their contexts. Similarly, Uushona (2012) used indigenous fruit to make a traditional liquor called *Ombike* through the process of fermentation and distillation. In Uushona's study, it emerged that conceptual understanding and sense making were enhanced. Shifafure (2014) too, conducted a study using *Kashipembe*, a traditional beverage used in Kavango. His findings echo those of Kambeyo (2012), Klein (2011), and Uushona (2012).

A number of South African science teachers have also conducted case studies using easily accessible resources to conduct practical activities in the science classrooms (e.g. Kuhlane, 2011; Maselwa & Ngcoza, 2003; O'Donoghue, et al, 2007). To this end, Maselwa and Ngcoza used easily accessible resources such as old transparencies in their study on practical activities in electrostatics in Physical Science. Asafo-Adjei (2004), an Agricultural Science teacher looked at changing wild vegetables (*imifino*) to cultivated vegetables (*umfuno*). Hanisi (2006) used an indigenous fermented beverage called *Umqombothi* in Life Science to teach the concept of fermentation.

A Nigerian case study involving six science teachers, two from each of the subjects Physics, Chemistry and Biology also looked at local indigenous activities in relation to their subjects. Students and teachers were taken to local sites to observe activities related to what they learn at school, namely, metal production, food and textiles. The study revealed that students were excited to be at the sites and were able to find relevance in what they studied in their classrooms with their local contexts (Erinosho, 2013).

Similar findings were also revealed by studies conducted in South Africa on the use of easily accessible resources (Lotz-Sisitka & Russo, 2003; Lotz-Sisitka, Olvitt, Gumede, & Pesanayi, 2006; O'Donoghue, et al, 2007). The use of easily accessible resources also ensures education which is locally relevant and culturally appropriate which empowers individuals and gives them a voice by unlocking their potential (Kibirige & van Rooyen, 2006; Mukwambo, et al., 2014). Based on the case studies described above, it is evident that there are advantages related to using easily accessible resources. When available resources are used to mediate learning, this deepens notions of inclusivity; it makes connections between what is being said and what is meaningful to the learners (Lupele & Lotz-Sisitka, 2012). This allows learners to participate in a wider variety of social practices. It also makes education relevant by putting the learning processes into context with the learners' living environment. The notion of inclusivity is also advocated by Kibirige and van Rooyen (2006), stating that all learners should be involved in science. Research has shown that students learn best when actively engaged in the learning process and these active approaches are more effective in developing students' ability for higher-order thinking tasks such as analysis, synthesis, and evaluations (Prince, 2004).

Seeing that the use of easily accessible resources is advantageous, Oloruntegbe and Ikpe (2011) found that there is a need for teachers to consciously help students during science lessons to bridge the divide between school science and household activities. They hold that if students are not exposed to purposeful hands-on activities, they may not be able to relate science to life at home. They posit that a broad array of household activities are a good source of meaningful, experiential-based teaching and learning and in-depth understanding of scientific concepts, which is in itself the use of easily accessible and familiar resources (ibid).

In the next section, the conceptual framework which underpins my study is discussed.

2.3 Conceptual frameworks

According to Bertram and Christiansen (2015), a conceptual framework is a set of ideas or concepts that guide the research. Similarly, Jabareen (2009) describes a conceptual framework as a plane of interlinked concepts that together provide a comprehensive understanding of a phenomenon. Jabareen (2009) further adds that the concepts that constitute a conceptual framework support one another to articulate their respective phenomena. He also expresses that the concepts in a conceptual framework have certain features in the sense that each concept plays an integral role and provides understanding of the conceptual framework (ibid). For this study, the conceptual framework is comprised of the concepts of disposition and professional development which I now discuss below.

2.3.2 Disposition

The term disposition is used to describe tendencies/inclinations/beliefs to exhibit frequent, conscious and voluntary trends/patterns of behaviour which are directed to a broad goal (Atallah, Bryant & Dada, 2010; Crick &Yu, 2008; Katz, 1993). Knowledge alone is not sufficient justification of disposition, knowledge can be acquired without having the disposition to use it; there must be a desire to employ it (Crick & Yu, 2008; Katz, 1993). Thus, since not all dispositions are desirable, teaching practices must seek not only to strengthen the desirable ones but also to weaken the undesirable ones (Katz, 1993). For this study, I will focus my attention on three attributes of disposition to teaching.

One such attribute is *dimensions of personalities*. On this, Jung and Rhodes (2008) postulate that personal characteristics such as attitudes, values, wills and habits of mind affect dispositions. They further add that with regard to personal dimensions, dispositions can either be latent qualities or conscious controllable human responses. This is also echoed by Crick and Yu (2008) who state that a disposition can be identified in the action a person takes in a particular situation. This is in line with the findings of a study done by Shizha (2007) in Zimbabwe, in which he analysed problems encountered when incorporating IK in primary schools. It emerged that some teachers had negative attitudes towards the inclusion of IK in teaching and learning repertoires and confined themselves to teaching WS exclusively. It was proposed that there is a need for teachers to embrace a positive attitude towards the integration of IK in classrooms (Le Grange, 2007).

Another attribute is the habits of mind (*patterns of behaviour)*. In this regard, Jung and Rhodes (2008) explain that people need to have certain competencies (skills, ability, action) in order to have certain dispositions in certain behaviours. In the context of my study, this entails the ability to implement the activities carried out during the intervention as well as the skills and action taken to implement the activities. In relation to the use of easily accessible resources, Atallah, et al. (2010) indicate that real life experiences promote interest and confidence. Research was conducted in Hong Kong, Chinese Taipei, Japan, Korea and Singapore on the relationship between their eighth-graders' dispositions towards science and their performance in TIMSS. It emerged from the findings that their sense of enjoyment, valuing and confidence in science were directly associated with their higher performance on TIMSS than their counterparts who did not like science (Fah, Areepattamannil, Thoe, & Hoon, 2015).

Another attribute is *dispositions as cultivated human quality*. Dispositions of people can be changed through educational experiences. This involves the ability of teachers to accept and embrace change (Jung & Rhodes, 2008). Jung and Rhodes (2008) add that although teacher educator programmes cannot work on teachers' feelings towards collaborative work, they attempt to provide relevant educational experiences and training so that candidates can be more competent in using collaborative strategies. For instance, in research on teachers' dispositions towards an indigenised science curriculum, Ogunniyi and Hewson (2008) found that after a six month exposure to an argumentation-based course, teachers were more willing to accept Indigenous Knowledge Systems (IKS) as a potentially legitimate aspect of the science curriculum. Teachers were also more able to distinguish between science and IKS and were more aware of the appropriateness of context after the course than before. Hanisi (2006) also indicates that she developed the interest and curiosity to use *Umqombothi* in Life Sciences to teach alcoholic fermentation after she participated in a science education module which involved the science of fermentation. Similarly, in a study conducted in Eastern Cape, South Africa on learners' participation in science expos, it emerged that learners who participate in science expos develop positive dispositions to study science at school (Ngcoza, Sewry, Chikunda & Kahenge, 2016).

The attributes of disposition as a *cultivated human quality* (Jung & Rhodes, 2008) is linked to professional development and this will be discussed in the next section.

2.3.3 Professional development

According to Mizell (2010), professional development usually happens during formal processes such as a conference, seminar, workshop, collaborative learning among members of a work team or a course at a college or university. Professional development is not always confined to formal platforms but can also occur informally such as during discussions with work colleagues, independent reading and research, learning from a peer and observations of a colleague's work (ibid).

Harwell (2003) states that professional development is not an event, it is a process, and should always address identified challenges in terms of teachers' classroom practices in a way that leads to improvement in students' achievements. These practices include curricula and instructional strategies that deepen teachers' subject content knowledge and teaching skills to enable teachers to be on par with the developments in their respective subjects and education in general (ibid). In this respect, professional development is regarded as a concept of development which is *about* educators, *for* educators, *by* educators, *with* educators, (Ngcoza & Southwood, *in progress*).

A large body of literature recommends that many problems facing science teaching and learning today could be resolved through professional development (e.g. Ngcoza, 2007; Ogunniyi & Ogawa, 2008; Shizha, 2007).

To this end, Ngcoza (2007) in his case study conducted in South Africa, worked collaboratively with eight (8) teachers in establishing a science teachers' transformative and continuous professional development (TTCPD) network with the aim of capacity building and reflexive practice. It emerged from his case study that teachers need empowerment opportunities in order to enhance their pedagogical, and science content knowledge as well as conceptual development. Science teachers' transformative and continuous professional development based on participative approaches and mutual collegial support are regarded a crucial, and that teachers' sociocultural contexts and experiences should be taken into consideration during this process (ibid).

With similar views, Shizha (2007) recommends that, if for instance, teachers are expected to practise the inclusion of IK in their classrooms, this should start at teacher training level by means of transformation of current practices such as establishing centres for IKS in tertiary institutions for both trainees and IK researchers. Institutions of higher learning, in particular education faculties, have been called upon to produce skilled personnel capable of embracing and incorporating IK into the teaching and learning processes (Ogunniyi & Ogawa, 2008). Vhurumuku and Mokeleche (2009) argue that there is a need for student teachers and practising teachers to understand the relevance of IK in curricula which could be encouraged through professional development.

Similarly, Oloruntegbe and Ikpe (2011) highlight that teachers need to be trained in how to improve the use of students' home experiences in such a way that students will clearly see the connections between the home experiences and school science. Similarly, Kasanda, et al. (2005) suggest that programs preparing teachers need to pay more attention to supporting teachers for LCE. Empowering teachers to design relevant curricula for specific communities requires more attention and it opens up many possibilities for teacher education and professional development (Leach & Scott, 2003; Stears, et al., 2003). Science teachers, textbook authors, teacher trainers and curriculum planners need to create opportunities for establishing a bridge between school science and household chores (Oloruntegbe & Ikpe, 2011).

Johnstone (2010) verbalises that despite 40 years of research in chemistry education for instance, problems identified in the 1970s still persist today and that this should tell us something about the direction we are taking and the need to change. This highlights the need for more professional development than ever before.

In the next section, the theoretical framework which underpins my study is discussed.

2.4 Theoretical frameworks

Sinclair (2007) refers to a theoretical framework as being similar to a map or travel plan. Theoretical frameworks are different structures around which research can be designed and conducted and influence every aspect of the research (Merriam, 2009). The frameworks affect how the study is designed, and how empirical data are collected and analysed (Bertram & Christiansen, 2015). This study is based on Vygotsky's (1978) sociocultural theory and Shulman's (1986, 1987) theory on pedagogical content knowledge (PCK). These will now be discussed.

2.4.1 Sociocultural perspective

Vygotsky (1978) strongly believes that a community plays a central role in the process of making meaning through social interactions. His emphasis is that culture affects and shapes cognitive development because the environment in which children grow up will influence their thinking. Lemke (2001) concurs by stating that in terms of the sociocultural perspective, science should be viewed as a human activity which is situated in larger communities and cultures, extending beyond the classroom.

This theory emphasises the importance of context in teaching and learning. Meaningful learning happens when the interactions between individuals or as individuals operate in social contexts that engage with cultural products which are made available to them in their contexts (Jaworski, 1993; Leach & Scott, 2003; Turuk, 2008). Learning is embedded in societies in which individual learning takes place in social actions and interactions through what is referred to as communities of practice (Lave & Wenger, 1991).

Aikenhead and Jegede (1999) argue that in order to acquire the culture of science, students must move freely between their everyday life worlds to the world of science found in their classrooms.

They add that students need to travel between these two worlds with flexibility, playfulness and feelings of ease in order to be able to smoothly cross borders into the culture of science. The smoothness in terms of border crossing into school science in turn enhances effective collateral learning (Aikenhead, 2001). Kibirige and van Rooyen (2006) strongly agree with these views.

2.4.2 Pedagogical Content Knowledge (PCK)

The notion of PCK is attributed to Shulman (1986, 1987). He identifies seven categories of teacher knowledge, namely, subject matter knowledge (SMK), pedagogical content knowledge (PCK), curriculum knowledge, general pedagogy, learners and their characteristics, educational contexts and educational purposes (Shulman, 1987).

Shulman (1986) stipulates that in order for teachers to be able to effectively mediate learning, they should know the best strategies to employ to make the content easily accessible to learners, enabling them to make meaning of the concepts under study. He also points out that for teachers to be able to use resources, they should have a good knowledge of the resources. He also emphasises that a teacher is someone who knows something that is not understood by others (usually their students) and that a teacher should know what is to be learned and how it is to be taught. In agreement, Hewson (1992) states that for effective teaching of science, it is the teacher's responsibility to engage in teaching practices that facilitate conceptual change to occur. Conceptual development is more likely to take place if the planned activities are relevant to the context (Leach & Scott, 2003).

Shulman (1986) further describes other factors that affect PCK. SMK is identified to be preceding PCK. In order for a teacher to develop good PCK, they should have a strong foundation of the SMK. Another factor is curriculum knowledge. One needs to have a comprehensive knowledge of the curriculum and its expectations in order to enhance PCK. He also identifies learners' characteristics as it is also necessary to understand the types of learners in terms of their background, culture, language, learning style and so on to be able to help them in ways that are familiar to them. This also enables the teacher to develop cognizance of possible misconceptions or pre-conceptions that learners bring to the classrooms. Hewson (1992) encourages that prospective teachers are expected to develop conceptions of teaching based on their own experiences as students in many different classrooms, from courses in teacher education programs and as student teachers.

Van Driel (2010) states that there is a need to structure teacher education programs to promote the development of PCK. He further argues that professional development, prior work experiences, beliefs about students, beliefs about learning and time constraints all affect PCK. He supports the idea of using hands-on activities which develop sense making when mediating learning. He also adds that instruction tends to be more effective if familiar examples which learners are able to understand easily, are used. A teacher should be able to use resources which are available and familiar to the learners in their contexts. This understanding enables the teacher to develop the best strategies for helping these learners. This relates well with the sociocultural theory, which focuses on the importance of context.

In resonance with PCK, Aikenhead and Jegede (1999) advise that teachers need to develop culturally sensitive teaching methods that reduce any foreignness felt by students. They point out that the success of science courses depends on among others, the assistance that students receive from teachers in making transitions between their everyday knowledge and the science they are taught in schools.

2.5 Concluding remarks

The aim of this chapter was to look at the literature that informs my study. Firstly, I looked at the expectations of the NCBE in terms of prior everyday knowledge, practical activities and the use of easily accessible resources. From the results of this information it could be seen that the NCBE prescribes that during the teaching and learning repertoires, teachers should capitalise on learners' prior knowledge, drawing on examples from learners' local environment as learners do not come to school with no prior knowledge. Also, the syllabuses for the natural sciences subjects state that practical activities are mandatory for the science subjects. Secondly, I looked at the various concepts which inform my study, namely, conceptual development, disposition and professional development. In this regard, it was observed that the degree to which science teachers conform to the prescriptions of the NCBE is highly influenced by their conceptions and experiences as well as their dispositions towards practical activities in science. This provided insights and highlighted the merits of professional development. Lastly, I looked at the theoretical framework that informs my study, namely, Vygotsky's (1978) sociocultural theory and Shulman's (1986, 1987) theory on PCK. In order for teachers to embrace the ideals of the NCBE, there is a need for change in terms of their PCK. This change should be guided by sociocultural theory because there is a need to draw on examples from local context, to enhance LCE.

In the next chapter, the research methodology employed in my study is described.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

In this study, I embarked on a journey to explore how an intervention using easily accessible resources to carry out practical activities might influence science teachers' conceptual development and dispositions towards the use of practical activities in science. In order to accomplish the task I needed to use a mixed methods case study approach within the interpretive paradigm to gather data.

In this chapter, I elaborate on the methodology adopted in my enquiry. To begin with, the research design and orientation are explained. A profile of the research objectives, goal and questions follows. A narrative of the research site and participants as well as data gathering and analysis techniques are provided. Finally, the validity and ethical issues which were taken into consideration, as well as limitations of the study are discussed.

3.2 Research design and orientation

A research design is a plan of how the researcher will systematically collect and analyse the data that is needed to answer the research questions (Bertram & Christiansen, 2015). There are certain criteria that a research design must meet. One criterion is the type of evidence or data that the researcher needs to collect in order to arrive at the answers to the research question(s). Secondly, the research design should stipulate the methods that the researcher will employ in order to collect the expected data. Also, the design should indicate what the researcher will do with the data once it has been collected, in other words how the analysis of data will be carried out (ibid).

My research was conducted in three phases. It was a mixed methods case study underpinned by an interpretive paradigm. In the first phase, I handed out questionnaires to my research participants to complete (see Section 3.2.3). The aim of the questionnaire was to discover the experiences of teachers regarding practical activities, including the use of easily accessible resources. I also analysed documents such as the Namibian National Curriculum of Basic Education (NCBE), syllabuses and subject policies for Physical Science, Life Science, Biology, Natural Science and

Health Education (NSHE), Agricultural Science as well as examiners' reports to strengthen the context of my study (see Sections 1.2.2.1 and 1.2.2.2). In the second phase, I co-designed and adapted activities with my co-researcher on practical activities using easily accessible resources. We used ideas from the workshops we attended in Grahamstown in August 2015 where we did activities with Mrs. Joyce Sewry and Mr. Richard Grant. My co-researcher and I planned these activities in order to carry out an intervention in the form of a workshop together with our participants. At the end of the intervention, participants were given questionnaires to capture their reflections on the intervention. I also interviewed three participants after the intervention. In the third phase, I did a follow-up study with two of the participants in order to observe how they implemented the activities. I interviewed both the participants at the end of the observation period and their learners also had an opportunity to reflect on the activities.

In Phase 1, a questionnaire was administered to 21 participants in order to ascertain their experiences regarding practical activities from their studies and teaching experience (see Appendix B1). An additional objective was to determine what factors influenced their experiences. The questionnaires were first piloted with my fellow MEd classmates. According to Creswell (2012), a pilot test allows the researcher to change the instrument based on the feedback from a small representative sample. The purpose of this pilot was to ensure that the questions in my questionnaire were clear and unambiguous. When I received the questionnaires from my classmates, I realised that some questions needed to be changed. For instance, instead of asking how teachers taught the fact that carbon dioxide has a *sour taste*, I had to rephrase it to 'carbon dioxide is *acidic*'. This was based on a response from the pilot test participants that 'we are not allowed to *taste* things in the laboratory' whereas I was looking at their experiences on conducting practical activities to show that carbon dioxide gas is acidic and not necessarily about *tasting*.

In the following section I discuss the research paradigm employed in this study as well as the reasons for adopting a case study approach within an interpretive paradigm.

3.2.1 Interpretive paradigm

The design for this study was within the interpretive paradigm whose premise is that "the way in which people respond to a given situation depends largely on their past experiences and circumstances; thus their context is very important" (Bertram & Christiansen, 2015, p. 25). The purpose of interpretivists is to comprehend the meanings that inform human agency, behaviour, attitudes, beliefs and perceptions, which in turn influences the methods they choose (ibid). In the same vein, Cohen, Manion and Morrison (2011) express that the interpretive paradigm has to do with understanding human experiences from within the individual's intentional behaviours and actions. The purpose of my study was to gain insight into the conceptions and experiences of the participants in terms of carrying out practical activities, whether they do carry out practical activities during their teaching or not. In addition, I also wanted to find out what factors influence their actions and conceptions based on their experiences and circumstances.

Data gathering techniques such as observations and interviews are typical techniques associated with the interpretive paradigm and thus were suitable methods to collect data in order to answer my research questions. It was necessary for me to make observations during the intervention as well as during the implementation phases. These techniques are therefore dependable with the interpretive paradigm. In the interpretive paradigm, data is collected in real and authentic situations which leads to explanations of behaviours, motives, perceptions and experiences (Bertram & Christiansen, 2015). In this study, I also observed the behaviour of the participants during the intervention, whether they were enthusiastic or not and their reactions to the activities in the intervention.

3.2.2 A mixed methods case study

A mixed methods case study design (quantitative and qualitative data were collected) was adopted for my study. "A case study provides a unique example of real people in real situations" (Cohen, et al., 2011, p. 289). Case studies look at what it is like to be in a particular situation, so they are generally descriptive in nature (Bertram & Christiansen, 2015, p. 42). A case study also provides a researcher with a deeper understanding of the dynamics of a situation (Maree, 2011). In this case, the study aimed at gaining some insights into the experiences of participants in conducting practical activities. In addition, the study also aimed at understanding the factors which influence these experiences. The study thus sought to explore how an intervention in the form of a workshop influences these conceptions and experiences and how participants implement the use of easily accessible resources after exposure to the use of these resources.

This is a mixed methods case study in the sense that the data collected was both qualitative and quantitative in nature. A mixed methods approach was preferred for this study to ensure that quantitative and qualitative data complemented each other (Maree, 2011). In this case, the data were gathered initially throught questionnaires (Phase 1), from which quantitative data emerged. Analysis of the gathered data informed the development of the intervention in the form of a workshop (Phase 2). Qualitative data from Phases 2 and 3 then sought to gain comprehension of how the intervention influenced the conceptual development and dispositions of the participants towards the use of hands-on practical activities in the science classrooms. Johnson and Onwuegbuzie (2004) affirm that mixed methods research is a natural complement to qualitative and quantitative research.

Althought mixed methods by nature, the study gave more priority to qualitative approaches (QUAL) as compared to quantitative approachers (quant) which were used to a lesser extent.

3.2.3 Phase 1: Experiences of participants

In this phase, the intention was to unearth experiences of participants regarding practical activities in the science classroom. This was aimed at establishing whether participants do carry out practical activities or not during their lessons. Furthermore, to determine what factors enable or constrain them from carrying out practical activities in their science classrooms. In his study conducted in South Africa, Ngcoza (2007) found that the ways in which teachers were taught influenced to a large extent their classroom practices. This is similar to the findings of Shizha (2007). The experiences found in Phase 1 influenced the planning of Phase 2.

3.2.4 Phase 2: An intervention in the form of a workshop

At this stage, my co-researcher (Section 3.2) and I arranged a workshop in which we planned practical activities to carry out with the participants. The aim of this intervention was to create a platform of exposure to the use of easily accessible resources to conduct practical activities in the classroom and to establish how this exposure influenced the participants' dispositions towards practical activities in science. As explained in the literature review (see Section 2.3.4), this intervention was aimed at creating a professional development platform with the participants.

3.2.5 Phase 3: Observations on the particpants' teaching

The third phase was concerned with gaining some insights into the science teachers' practice in their classrooms in terms of implementing the activities learnt from the workshop. Phase 3 was thus a follow-up on Phase 2. At the end of the workshop, I asked for two teachers to volunteer for a further study. One male teacher and one female teacher who both teach in the northern part of Namibia volunteered. One of the participants (who took part in Phase 1 of the study but was on sick leave during Phase 2) also volunteered to participate in the follow-up study based on the feedback she was given by the other participants on the workshop. Eventually, for convenience purposes, I did a closer study with the one participant, a teacher from a seconday school in Okahandja and with one of the two who volunteered from the north. During this phase, I observed three lessons presented by each of the participants. Learners also wrote some reflections at the end of the data collection to describe their experiences on the practical activities.

3.3 Research goal, objectives and questions

3.3.1 Research goal

The main goal of my study was to explore how an intervention on using easily accessible resources in carrying out hands-on practical activities in science influences science teachers' conceptual development and dispositions towards use of practical activities in science.

3.3.2 Research objectives

The objectives of my study were:

1. To explore the experiences of science teachers regarding practical activities in the science classroom;
2. To identify the factors which influence science teachers' experiences regarding practical activities in the science classroom;
3. To explore how an intervention in the form of a workshop on the use of easily accessible resources (to carry out practical activities in the science classroom) influences science teachers' conceptual development and dispositions towards practical activities in science
4. To explore the possibilities of this approach (intervention in the form of a workshop) to teachers' Continuous Professional Development (CPD) in the Namibian context.

3.3.3 Main research question

How does an intervention using easily accessible resources (in carrying out hands-on practical activities in science) influences science teachers' conceptual development and dispositions towards practical activities in science?

Sub-questions:

Phase 1: Before the intervention:

1. What are science teachers' experiences of doing hands-on practical activities in their science classrooms?
2. What factors influence science teachers' experiences of doing hands-on practical activities in their science classrooms?

Phase 2: Intervention in the form of workshops for one week

3. How did the intervention in the form of a workshop influence science teachers' conceptual development and dispositions towards practical activities in science?

Phase 3: Implementation of practical activities by teachers in the classroom

4. What factors enable or constrain science teachers when mediating learning using easily accessible resources to carry out hands-on practical activities in their science classrooms?

3.4 Research sites, participants and sampling

I conducted the research with 21 teachers from different schools in Namibia who were all in a BEd (Honours) program at a certain university in Eastern Cape, South Africa. In the following sections, I describe the research site, research participants and sampling method in more detail.

3.4.1 Research sites

Phase 1 and Phase 2 of the research were carried out at the National Institute for Educational Development (NIED) in Okahandja. NIED is a directorate within the Ministry of Education, Arts and Culture, whose mandate is curriculum and professional research and development. It is at this site where the contact sessions for the Namibian BEd and MEd programs are conducted. In Phase 3, the research was carried out at the schools of the two participants who volunteered for closer study. These two sites were two different secondary schools in Namibia. One of the schools, Millenium Secondary School (pseudonym) is situated in Okahandja, Otjozondjupa region, central Namibia. The other secondary school, Hope Secondary School (pseudonym) is situated in Oshikoto region in northern Namibia. The teachers assigned the pseudonyms to the schools themselves. Millenium Secondary school is a well performing school among the top ten best schools in the region. Hope Secondary School is a newly expanded secondary school. It used to cater for grades 8-10, and in 2016 their curriculum was expanded to include grade 11.

3.4.2 Research participants

The research was carried out with the entire science elective class of 21 teachers who all were doing the BEd (Honours) program with a certain University in Eastern Cape, South Africa. An intervention in the form of workshops was carried out at NIED in Okahandja where the participants and I attended face-to-face contact sessions. Of the 21 participants, 10 teach Physical Science (also Mathematics in some cases) with experience ranging from 1 to 10 years, with an average of 5.5 years teaching experience in Physical Science. Nine of the participants teach one of life science subjects such as Biology, Natural Science and Health Education and Agriculture, some of whom have also at some point assisted with the teaching of Physical Science. Two of the participants teach only Mathematics although they have also specialised in Science at tertiary level. As mentioned earlier, the two participants whose lessons I observed are teachers from different schools in different regions in Namibia.

As I explained in Section 3.5, in this study I was afforded an opportunity to look at the expectations of the students doing the BEd (Honours) Science Elective course. The following are extracts from the expectations of participants when they first attended the course in January 2016.

TABLE 3: A SUMMARY OF PARTICIPANTS' EXPECTATIONS OF THE COURSE

- *To gain experimental skills;*
- *To be equipped with science subject content;*
- *To be able to carry out science projects/research;*
- *To be able to identify problems within the field of science;*
- *To be able to improve the teaching of science in Namibian context;*
- *To be aware of science teaching methodologies;*
- *To know what constitutes science;*
- *To learn skills of becoming an effective science teacher;*
- *Learning more about indigenous science;*
- *To share interest on how to improve learners' interest in science;*
- *Gain more knowledge in the science subject content;*
- *Gain more knowledge on how to become better science researchers;*
- *Improve knowledge of science methodologies;*
- *Variety of teaching methods;*
- *Developing creativity;*
- *Gain more knowledge and skills in science;*
- *Improve research methods; and*
- *Address challenges in science education.*

From the expectations of the participants, I could see that in general, all the participants would like to gain innovative, creative and improved skills and expertise from the course in order to become better science teachers. For instance, they indicated that they expect '*to gain experimental skills*', '*to carry out science projects/research*', '*to learn skills of how to become an effective science teacher', to have improved knowledge on science methodologies', to learn a variety of teaching methods and 'to develop creativity'*. Furthermore, they all seem to share the premise that there is a need to improve science education in Namibia as they indicated that they would like to, '*identify problems within the science field*', '*to share interest on how to improve learners' interest in* *science'*, '*address challenges in science education*' and '*to be able to improve the teaching of science in the Namibian context*.

The expectations of these participants resonate, to a large extent, with the significance of my study (see Section 1.4).

3.4.3 Sampling

Sampling involves making decisions about who to include in the study (Maree, 2011). In my case, I made use of a combination of purposive and convenient sampling strategies (Cohen, et al., 2011). Purposive sampling decisions include selection of participants, setting, incidents, events and activities to be included for data collection (Maree, 2011). I used purposive sampling in the sense that all the students in the study were at the time of this study doing the BEd (Honours) Science elective as part of their course and I was looking at doing my research with science teachers in Namibia. Since I was also part of the BEd (Honours) program, I was aware that on the first day of the course the lecturer asks students to discuss their expectations of the science elective course. Hence, I was afforded an opportunity to look at the students' expectations from the science elective course to find out whether their expectations resonate with my research.

Coincidentally, among others, some of the students' expectations of the science elective were: "*to gain experimental skills, to be able to improve the teaching of science in the Namibian context, to be aware of science teaching methodologies, to learn skills of becoming an effective science teacher, learning more about indigenous science, to share interest on how to improve learners' interest in science, variety of teaching methods, developing creativity, address challenges in science education*" as reflected in Table 3 above. These expectations triggered my interest and curiosity to consider doing my research with these students as I felt that their expectations resonated with the objectives of my study. It was also convenient because the students and I attended our sessions at NIED in Okahandja. As a result, it was easy for me to have access to them in order to conduct intervention workshops at one site. On convenience sampling, Neuman (2011) posits that this is a non-random sampling method in which the researcher selects suitable participants whom they come across.

3.5 Data gathering techniques

The data for this study was collected in three phases. For my baseline data (Phase 1), I used questionnaires to collect data. I also used documents to strengthen my context. For my main study (Phase 2), I used the following data gathering techniques: an intervention in the form of workshops which were videotaped, semi-structured interviews followed by reflections. For Phase 3, I used observations of videotaped lessons, followed by semi-structured interviews and learners' reflections. I gathered the data as outlined in the following table:

TABLE 4: THE VARIOUS PHASES OF THE DATA GATHERING PROCESS

Stage	Method used to gather data	Data to be gathered	Purpose	Research questions
Phase 1	A) Document analysis: curriculum documents e.g. national curriculum of basic education, syllabi, examiners' reports	What the documents say about the formation of carbon dioxide gas as well as how to carry out practical work on that concept.	To find out the curriculum requirements on the topic on the formation of carbon dioxide and practical work in the syllabi. To find out comments in examiners reports related to the topic.	Data from documents used to strengthen my context.
	B) Course expectations of participants	What they expect from the BEd Honours science elective course	To gain insight into what their expectations for the course are so that I could determine whether my research project is in line with their course expectations.	Data on course expectation s used to strengthen the context
	C) Questionnaires to the participating teachers	The teachers' conceptions and experiences regarding the topic and teaching of the topic	To explore the prior knowledge of participants in the topics and their prior use of and disposition towards using practical work in their science classrooms.	To answer research questions 1 and 2
Phase 2	**Intervention** Observations of participants during the workshop which will be videotaped.	 To observe how the workshop influences the	 To see the participants' perceive the experience	 Research question 3, 4

	Questionnaire at the end of the workshop to do reflections on the workshop Semi-structured interviews with 3 participants after the intervention	engagement of the participants Views and experiences of participants about the intervention Engagement and participation during the workshop Views about the interventions	To see how they react to the intervention and understanding of concepts and to note any changes in their disposition towards practical work as well as insights into possibilities for continuous professional development To find out whether the intervention was helpful or not and whether there were any changes in their dispositions	
Phase 3	**Teaching** Two teachers for closer study Observations and videotaped lessons when the two teachers use easily accessible resources in practical work Semi-structured interviews with the two teachers	The way the teacher uses easily accessible resources to conduct the lesson and the impact it has on leaners Their experience on how they use easily accessible resources to facilitate the topic To explore what enabled them and constrained them during the implementation of these activities	To find out the factors that enable or constrain teachers when mediating the topic using easily accessible resources To get clarity and for further explanation of things to validate the data gathered through the above mentioned methods Possible changes in their disposition towards practical work	Research question 5

I now discuss each of my data gathering techniques in detail in relation to the phases or the data gathering process.

3.5.1 Document analysis

According to Bertram and Christiansen (2015), "researchers can use various existing documents as their source of data for example examination papers, teachers' daily journals, learners' workbooks, school policy documents, curriculum statements, textbooks, *etcetera*" (p. 97). In this phase, I analysed the Namibian National Curriculum for Basic Education (NCBE) to determine the curriculum expectations regarding practical activities, prior everyday knowledge and the use of easily accessible resources. The curriculum documents I looked at were the syllabi for Natural Science and Health Education (NSHE) grades 5-7 and Physical Science grades 8-12, Life Science grades 8-10, Biology grades 11-12. I also analysed the examiners' reports for grade 10 Junior Secondary Certificate (JSC) examination, Namibian Senior Secondary Certificate Ordinary level (NSSCO) and Namibian Senior Secondary Certificate Higher (NSSCH) level. From these data, I found that in general, the curriculum, being underpinned by the learner centred education pedagogy, stipulates that learners' prior knowledge should be included in the teaching and learning processes. However, the syllabuses, based on the suggested practical activities, do not explicitly mention examples of practical activities using easily accessible resources; rather the focus is more on conventional laboratory chemicals and equipment. Also, the examiners' reports revealed that learners are not properly prepared in terms of practical activities, as the knowledge they demonstrate through responding to examination questions appears superficial (Namibia. MoE, 2010-2014 reports).

3.5.2 Questionnaires

According to Bertram and Christiansen (2015), a questionnaire can contain either closed ended questions, open-ended questions or a combination of both open ended and closed ended questions as questionnaires are used to obtain survey information providing mainly numerical data (Cohen, et al., 2011). In the case of my study, the questionnaires consisted of both open-ended and close-ended questions (see Appendix B1) as described by Bertram and Christiansen (2015). The questionnaires that I used were first piloted with six of my MEd colleagues in order to confirm whether the questions were clear and understandable to the reader. The pilot questionnaire revealed that one of my questions was not clear based on the response I got from my colleagues. One of the questions required participants to describe how they were taught that "carbon dioxide has a slightly *sour taste*". One respondent wrote "we are not allowed to taste things in the laboratory". This is not what I was looking for and so I had to rephrase my question to read, "carbon dioxide is slightly *acidic*" because it appeared that the *sour taste* implied that they had to *taste* the carbon dioxide.

The pilot test also helped me to clarify all my questions because my pilot questionnaire had a main question and sub-questions such as "what are your experiences on" and then the sub questions follow independently for example "preparing carbon dioxide; testing that carbon dioxide has a slightly sour taste, testing that carbon dioxide does not support combustion". I was advised by my colleagues that I should include the stem in each of the sub-questions so that each sub-question was complete and the reader did not have to refer back to look at the stem. I found this pilot test quite useful in terms of clarifying the questionnaires and making them as reader-friendly as possible. This is in line with Bertram and Christiansen (2015) who suggest good practices for administering a questionnaire that it is piloted with a small sample before it is administered to a large sample. This ensures that the questionnaire asks for the required information clearly and unambiguously.

I administered the questionnaires directly, the participants completed the questionnaire in about 2 hours and returned them at the end of the session (Bertram & Christiansen, 2015). During this time, two of the participants had to leave to attend a funeral. I was able to assist the rest of the participants with parts of the questions that needed clarity. This strategy helped me in terms of the return rate of the questionnaires because out of 21 students, I managed to get 21 questionnaires back. I have learned from this process that if questionnaires are piloted, participants are more at ease to respond to the questions and very few participants would need further explanations. I have also learned that even if the questionnaires are well piloted, there will always be one or two people who still need help so it was an advantage for the researcher to be present.

3.5.3 Observations

With observation, the researcher goes to the site of study and observes what is actually taking place to obtain first-hand information (Bertram & Christiansen, 2015). In this case I used observations during the intervention as well as during the classroom observation stages to examine what was actually taking place.

3.5.3.1 Observations on the intervention in the form of a workshop

The workshop was conducted over five days. The activities were carried out in a period of four days. On the fifth day there was a workshop on assessment for learning which was the focus for my co-researcher. The sessions ranged from one hour thirty minutes to two hours per session per day. During the workshop, we carried our practical activities using easily accessible resources. Participants worked in groups of 5. Participants had to complete worksheets individually and then as a group in order to make predictions about the prepared activities as well as explanations for their predictions. In addition, they also had to make observations and give explanations for their observations of the practical activities. Participants also had to come up with concept maps and mind maps on the concepts which emerged from the activities.

Table 5 below summarises the activities conducted during the workshop.

TABLE 5: SUMMARY OF PRACTICAL ACTIVITIES CONDUCTED DURING THE WORKSHOP

Activities conducted	Easily accessible resources used
Day 1 • Preparation of the traditionally brewed beverage called Ontaku/Oshikundu	• *Omahangu* flour • Flour from *Omahangu*/Sorghum germinated seeds • Residue from already fermented *ontaku*/*oshikundu* called *oshipithitho* • Hot water (just below boiling point) • Cold water (at room temperature) • Bucket • Plastic bottles x 4 • Balloons x 4
• Preparation of yeast and sugar solution	• A plastic bottle (preferably 2 litre) • Luke-warm water • Yeast sachet • White sugar

• Preparation of eggs in different liquids	• Brown sugar • About 6 eggs per group • Vinegar • Lemon juice • Coca cola • 6 x beakers • Distilled water
Day 2 • Testing for carbon dioxide gas prepared in 5 different ways	• From the *Ontaku/Oshikundu* practical activity (from day 1) • From yeast and sugar solution (from day 1) • From exhaled air • From reaction of vinegar and bicarbonate of soda ($NaHCO_3$); • From reaction of egg shells and hydrochloric acid
Day 3 • Observations of eggs in different liquids (from day 1) • Preparation of eggs (from day 1) and potatoes for osmosis	(finishing off tasks from day 1) • About 6 eggs per group • Vinegar • Lemon juice • Coca cola • 6 x beakers • Distilled water • Concentrated salt solution (salt sol.) • Concentrated sugar solution (sugar sol.) • Distilled water (water)
Day 4 • Preparation of hydrogen gas • Tea bags activity • Squashing can activity	• Caustic soda (sodium hydroxide) • aluminium foil • Balloons • Plastic bottles • Tea bags • Hot water (boiling point) • Cold water (preferably from the refrigerator) • Cool drink cans (preferably 340 ml or bigger) • A source of heat (methylated spirits) • A cold water bath

During the observations, one of our MEd colleagues videotaped all the lessons. My co-researcher took field notes as I facilitated the workshop. The workshop was quite an exciting experience as the participants were engaged in carrying out the practical activities such as completing the worksheets and working in groups to construct mind maps. They also had an opportunity to present some mind maps based on the concepts that emerged from the activities. In addition, as I was facilitating, the participants were actively involved in helping me to set up the apparatus and to carry out the practical activities. I did not do this alone but with the assistance of the participants.

3.5.3.2 Observations on the classroom teaching

During the classroom observations of the two participants for closer study (as will be explained in sections 6.3 and 6.4), I recorded some video clips while the teachers were presenting as well as took photographs while the learners were busy with activities We asked learners from other class groups to assist us in video recording the activities.

TABLE 6: SUMMARY OF PRACTICAL ACTIVITIES FOR MRS CONFIDENCE (PSEUDONYM) CONDUCTED DURING THE LESSON OBSERVATION

<table>
<tr>
<td rowspan="2">Practical lesson 1: Acidity, alkalinity and neutrality of different liquids

(materials brought by the learners)
Oros
Lemon and orange squeezed in water
Orange squeezed in water
Oshikundu
Engine oil
Vinegar
Bleach (JIK)
Arial washing powder solution
Cooking oil
Cool drink (Coca-Cola and Fanta)
Fabric conditioner
Methylated spirits
Tea
Coffee
Indigenous fruit juice (omafauwena)
Indigenous water melon juice
Fresh milk
Drink O-pop (sweet aid)</td>
<td>Practical lesson 2: Effect of acids, alkalis and neutral substances on uncooked eggs
(materials from practical lesson 1)
Caustic soda solution
Hydrochloric acid
Vinegar
Washing powder solution
Bleach (JIK)
Bleach (Domestos)
Salt water
Sugar water
Uncooked eggs</td>
</tr>
<tr>
<td>Practical lesson 3: Effects of strong acids, weak acids and water on white sugar
White sugar
Tap water
Vinegar
Hydrochloric acid (2 mol/dm^3)
Sulfuric acid (98% concentrated)</td>
</tr>
</table>

Indigenous dye suspension (*Oshidhe*) **(materials brought by the teacher)** Caustic soda solution Hydrochloric acid Vinegar Washing powder solution Bleach (JIK) Bleach (Domestos) Salt water Sugar water Tap water Lemon juice (100%)	Practical lesson 4: Preparation of hydrogen gas Aluminium foil Caustic soda

The practical activities selected for Mrs Confidence's lessons were influenced by the topic she was busy with at the time of observation because she does follow a specific scheme of work and year plan and during the time, she was busy with the topic on Acids, Bases and Alkalis in Physical Science grade 9.

TABLE 7: SUMMARY OF PRACTICAL ACTIVITIES FOR MADAM PHYSICS (PSEUDONYM) CONDUCTED DURING THE LESSON OBSERVATIONS

Practical lesson 1: Preparation and testing for carbon dioxide gas Gas from *ontaku/oshikundu* Gas from reacting vinegar and baking soda Gas from reacting egg shells and hydrochloric acid Gas from exhaled air Gas from Coca-Cola soft drink Lime water Balloons	**Practical activity 2 Effect of sulfuric acid on white sugar** Concentrated sulfuric acid (98%) White sugar **Practical activity 3: Preparation of hydrogen gas** Aluminium foil Caustic soda

Similarly, the practical activities for Madam Physics' lessons were also influenced by the topic she was busy with at the time of observation. I observed her when she was teaching the topics of formation of carbon dioxide and hydrogen gases. The preparation of these gases also include the study of acids, bases and alkalis and their chemical reactions which leads to the formation of gases.

Before the lesson observations, we co-planned the practical activities with each of the teachers because they were using examples of activities from the workshop. The two teachers still needed more clarity and guidance on the materials to prepare and to rehearse how to go about doing the activities. In addition, the teachers also asked their learners to bring some materials from home.

3.5.4 Semi-structured interviews

According to Maree (2011), a semi-structured interview usually requires a participant to answer a set of pre-determined questions and it also allows for probing and clarification of answers from the interviewee. At the end of the workshop (Phase 2), I conducted semi-structured interviews with three participants who volunteered to be interviewed. The main aim of the interviews was to dig further into the experiences of the three participants during the intervention. I wanted to find out what they enjoyed most during the intervention and what they found to be challenging during the intervention. Furthermore, I also wanted to know if they felt that these actities worth implementing in their own classroom situations.

Similarly, at the end of the implementation (Phase 3), I interviewed the two participant teachers that I had observed. My main intention was to discover the factors which enabled or constrained them from conducting practical activities using easily accessible resources during this period. I wanted to delve into the challenges they experienced during the implementation stage as well as the factors that enabled them to conduct practical activities using easily accessible resources.

3.5.6 Reflections

After the workshop, I gave guidelines (see Appendix E) for the teachers to reflect on the intervention. This was aimed at exploring their dispositions (views/feelings/attitudes) towards practical activities which they were engaged in during the workshop.

3.6 Data analysis

Data analysis is “the process of making sense of data” (Merriam, 2009, p. 175). This procedure is used to answer the research questions.

In Chapter 4, I made sense of the data gathered from questionnaires through organising it into categories which emerged. These categories were in terms of teachers' experiences from studies with regard to having been taught using of easily accessible resources (see Table 9 and Figure 1). I also categorised teachers' experiences of having taught using easily accessible resources (see Table 10 and Figure 2). Other categories which also emerged from the questionnaires are on the possible factors which enable or contrain teachers from conducting practical activities (see Table 11 and Figure 3). All these categories are in line with pedagogical content knowedge (PCK) which states that professional development, prior work experiences, use of hands-on activities and familiar examples all affect PCK (van Driel, 2010; Shulman, 1986, 1987).

In Chapter 5, I categorised the quantitative data in line with the experieces of participants on activities done during the workshop (see Figure 5) and the influence of workshop activities on participants' attitudes towards practical activities (see Figure 6). I also categorised the qualitative data into sub-themes (see Table 13) and themes which emerged from the sub-themes (see Table 14). To come up with these sub-themes and themes, I made use of the literature (e.g., prior everday knowledge, practical activities, use of easily accessible resources), the conceptual framework (disposition and professional development) and the theoretical frameworks (sociocultural theory and PCK). I made use of the sociocultural theory's interactions with products from the context (Vygotsky, 1978). Based on the participants' reflections on the workshop, I used teachers' cultivated human quality dispositions (Reference) to determine whether the workshop affected the teachers positively or negatively.

In Chapter 6, I categorise the qualitative data in a similar fashion to Chapter 5. The qualitative data was analysed into sub-themes (see Table 16) and eventually themes (see Table 17). I made use of the literature (prior everday knowledge, practical activities, use of easily accessible resources), the conceptual frameworks (disposition and professional development) and the theoretical frameworks (sociocultural theory and PCK). I also followed up on two of the participants when they implemented some of the strategies in the classroom to look at their attitudes towards the use of easily accessible resources after the intervention. Also during the implementation stage, I was be able to determine the challenges that they experienced during its enactment. These are in line with my research questions.

3.7 Validity and trustworthiness

The use of multiple methods of data collection strengthens the validity of the data (Maree, 2011). In my case, I made use of questionnaires, semi-structured interviews, observations of lessons which were videotaped and reflections. The questionnaires were piloted with six of my colleagues in the MEd group to determine if they were accessible to the readers and to ensure that the questions were unambiguous. Furthermore, while the participants were answering the questionnaires, I was present for clarification purposes. A few participants asked questions for clarity but the majority of the participants understood the questions and I believe that the piloting really helped in this regard.

3.8. Ethical considerations

Respect and dignity

I treated the identity of the participants with a high degree of anonymity and confidentiality. I state clearly in the letter of consent that participation in this study was absolutely voluntary and that even if they agreed at first, they had the right to withdraw at any time (see Appendices A and F1 to F3). I also tried by all means to ensure good communication with my participants and establish trust so that participants would feel at ease to work with me. I also stipulated that the data would be collected using recording devices for the purposes of observations and I took cognisance of the research time of the participants to ensure that I did not unnecessarily interfere with their work schedules.

Transparency and honesty

I clearly explained the purpose of the research to the participants so that they knew what they were agreeing to. On the letter of consent, I created a reply slip at the bottom of the letter which the participants signed to indicate that they were willing to participate (see Appendices A, F1, F2 and F3). I also emphasised that participation was voluntary.

Accountability and responsibility

In my research, my participants were the BEd Honours science elective cohort of a university in the Eastern Cape, South Africa. I communicated with the BEd Honours programme coordinator as well as my lecturer. Issues of power gradients were also discussed because I am a master's student, the participants might have been reluctant to deny participation because of my seniority in terms of study. Also, as I am working at NIED, the participants might feel coerced by my position to agree. I ensured that these issues of power gradients were addressed with my lecturer and the program coordinator.

Integrity and academic professionalism

I ensured that I collected genuine data and avoided fabrication, manipulation of data or misreporting. I also acknowledged others' work through adhering to referencing where I cite other authors' work.

3.9 Limitations of the study

Due to the size of the sample, I am cognisant that possible limitations in terms of generalising the study over a larger population could exist. However, I hoped to obtain useful insights in terms of the perceptions and experiences of teachers. In addition, I anticipated that the use of recording devices for data gathering purposes could make participants uneasy. Nevertheless, my prolonged presence in the classroom, I believe, reduced this effect.

3.10 Concluding remarks

In this chapter, I described my methodological orientation in which I explained the mixed methods case study approch situated within the interpretive paradigm. I also outlined my research goal, objectives and questions. I described the research site, participants and sampling and explained how the data were gathered and analysed. The issues of validity and trustworthines are also discussed. I culminated my study with an account of possible limitations. In the next chapter, I present and analyse and discuss the data for Phase 1.

CHAPTER 4: DATA PRESENTATION, ANALYSIS AND DISCUSSION (PHASE 1)

4.1 Introduction

As explained in the preceding chapters, the main goal of my study was to explore how an intervention in the form of a workshop, using easily accessible resources to carry out hands-on practical activities, influenced science teachers' conceptual development and disposition towards the use of practical activities in science. To achieve this goal, I gathered data in three phases and I made use of a variety of data gathering techniques as explained in the methodology chapter (see Sections 3.2.3, 3.2.4, 3.2.5 and Table 4).

In this chapter, I present a summary of quantitative data from Phase 1. This is aimed at answering my research sub-questions 1 and 2 which are:

1) What are science teachers' experiences of conducting practical activities in the science classroom?
2) What factors influence science teachers' experiences on conducting practical activities in the science classroom?

For Phase 1, my research participants were 21 Bachelor of Education (Honours) Science Elective students who are all enrolled with a University in the Eastern Cape Province, South Africa. I begin with the profiles of these 21 participants. This is followed by highlights of quantitative data obtained from questionnaires (see Section 3.5.2). The chapter culminates with some concluding remarks.

4.2 Teachers' profiles

The overall sample of teachers for Phase 1 consists of 21 teachers. Their profiles teachers are presented in Table 8. The codes used in the table, T1 to T21 represent participant teachers 1 to 21. The F and M at the end of the code represents their gender, that is F (female) and M (male).

TABLE 8: TEACHERS' PROFILES

Biographical information	Category	Teachers' code	Frequency
Age	20-25	T15M,	1
	26-30	T5M, T6M, T7F, T8M, T13M, T17F, T18F, T19F, T20F	9
	31-35	T1M, T4M, T9,F T10F, T11F, T12M, T14M, T21M	8
	36-40	T2M, T3M, T16M	3
Gender	Male	T1M, T2M, T3M, T4M, T5M, T6M, T8M, T12M, T13M, T14M, T15M, T16M, T21M	13
	Female	T7F, T9F, T10F, T11F, T17F, T18F, T19F, T20F,	8
Highest qualifications	BETD	T5M, T12M	2
	ACE/FDE	T1M, T2M, T3M, T4M, T6M, T7F, T8M, T9M, T10F, T11F, T13M, T14M, T15M, T16M, T17F, T18F, T19F, T20F, T21M	19
Qualification in Physical Science	BETD	T5M, T6M, T7F	3
	ACE/FDE	T1M, T2M, T3M, T4M, T8M, T9M, T10F	7
	None	T1M, T12M, R13M, T14M, T15M, T16M, T17F, T18F, T19F, T20F, T21M	11
Subject currently teaching	Physical Science	T1M, T2M, T3M, T4M, T5M, T6M, T7F, T8M, T9F, T10F	10
	NSHE, Life Science, Biology, Agriculture	T11F, T12M, T13M, T14M, T15M, T16M, T17F, T18F, T19F	9
	Mathematics	T20F, T21M	2
	1-5 years	T1M, T3M, T5M, T6M, T8M, T9F, T13M, T14M, T16M, T17F, T19F	11

Teaching experience in Physical Science	6-10 years	T2M, T4M, T7F, T10F	4
	None	T11F, T12M, T15M, T18F, T20F, T21M	6
Position	Teacher	T1M, T3M, T4M, T5M, T6M, T7F, T8M, T10F, T11F, T13M, T14M, T15M, T16M, T17F, T18F, T19F, T20F, T21M	18
	Principal	T2M	1
	AT	T9F, T12M	2

From the biographical information, 17 participants (81%) are between the ages of 26 to 35 years old so are relatively young. With regard to gender, 13 participants (62%) are males and 8 (38%) are females. In terms of their highest qualification, 19 participants (90%) possess either an Advanced Certificate in Education (ACE) or a Further Diploma in Education (FDE). The other 2 participants (10%) possess a Basic Education Teacher Diploma (BETD). In terms of qualifications in Physical Science, 7 participants (34%) possess an ACE or FDE, 3 (14%) possess a BETD and 11 (52%) of the participants do not have a qualification in Physical Science.

With regard to the subjects that the participants currently teach, 10 participants (48%) currently teach Physical Science, 9 (43%) currently teach either Natural Science and Health Education (NSHE), Life Science, Agriculture or Biology, and 2 participants (9%) only teach Mathematics. Of the 21 participants, 18 participants (86%) are teachers, 2 (10%) are advisory teachers and 1 (4%) is a principal. Their range in terms of teaching experience in Physical Science, 11 (71%) range from 1-5 years, 4 (19%) are in the range of 6-10 years and 6 (29%) have no experience in teaching Physical Science.

4.3 Quantitative results from questionnaires

To answer my research sub-questions 1 and 2, there were a number of questions in the questionnaire which required participants to express how they were taught various aspects on the topic carbon dioxide gas either from school when they were learners or from tertiary institutions (Universities and Colleges). They were also asked to describe how they teach the topic on the formation of carbon dioxide as well as to mention the factors which enabled or constrained them in teaching the topic using practical activities. The responses are summarized in line with the questions which were asked in the questionnaire. The questions were based on five basic practical activities about carbon dioxide. The responses of participants are classified into categories and quantified according to their answers. The topic on carbon dioxide was selected as it was seen as basic in all the sciences because of the understanding that the sample was comprised of teachers who specialised in different areas of Natural Sciences and Mathematics. It was seen that being subject specific was going to only be applicable to a smaller number of participants, therefore it was seen that there was a need to focus on a topic which is broader (i.e. carbon dioxide as a concept is taught in the subjects: Physical Science grade 8-12, Biology grades 11-12, Life Science grades 8-10 and NSHE grades 4-7). Therefore, teachers within these Natural Sciences subjects' specialisms would be having experience in having been taught or experience of teaching this topic.

4.3.1 Experiences from studies

The first question on part B the questionnaire required participants to state their experiences of having being taught the topic on carbon dioxide at school, college or university. They were asked to state the apparatus or chemicals used to carry out practical activities. This was aimed at establishing the factors which affect the participants' experiences of doing hands-on practical activities in their science classrooms (research sub-question 2). Their responses are summarised in Table 9 and Figure 1.

TABLE 9: EXPERIENCES OF HAVING BEEN TAUGHT THE TOPIC ON CARBON DIOXIDE GAS

Practical activities	Description of practical and conventional chemicals/apparatus	Mentioning of conventional chemicals/apparatus without description of practical	Use of alternative (easily accessible) resources to do practical	No practical done	No response

1 Practical on formation of carbon dioxide	T1M, T2M, T3M, T4M, T10F, T15M	T5M, T7F, T9F, T12M, T14M, T16M, T19F	T7F, T8M, T13M	T6M, T11M, T17F, T18F	T20F
2 Practical on acidic nature of carbon dioxide	T1M, T5M, T10F	T3M, T4M, T6M, T7F, T13M, T18F, T19F, T21M	None	T2M, T9F, T11F, T12M, T14M, T15M	T8M, T16M, T17F, T20F
3 Practical on CO_2 does not support combustion	T1M, T2M, T3M, T4M, T5M, T6M, T8M, T9F, T10F, T11M, T12M, T14M, T15M	T16M	T7F	T13M ,T15M, T17F, T18F, T19F	T20F
4 Practical on CO_2 is a greenhouse gas	None	None	None	T2M, T4M, T5M, T6M, T7F, T8M, T9F, T11M, T12M, T14M, T15M, T17F, T18F, T19F, T21M	T1M, T3M, T10F, T13M, T16F, T20F
5 Practical on respiration and photosynthesis in nature	None	None	T19	T1M, T2M, T3M, T4M, T5M, T6M, T7F, T8F, T9F, T11M,T12M, T14M,T15M, T17F, T18F	T10F, T13M, T16F, T20F, T21M

Figure 1 shows a graph of the data which is based on the responses summarized in Table 9

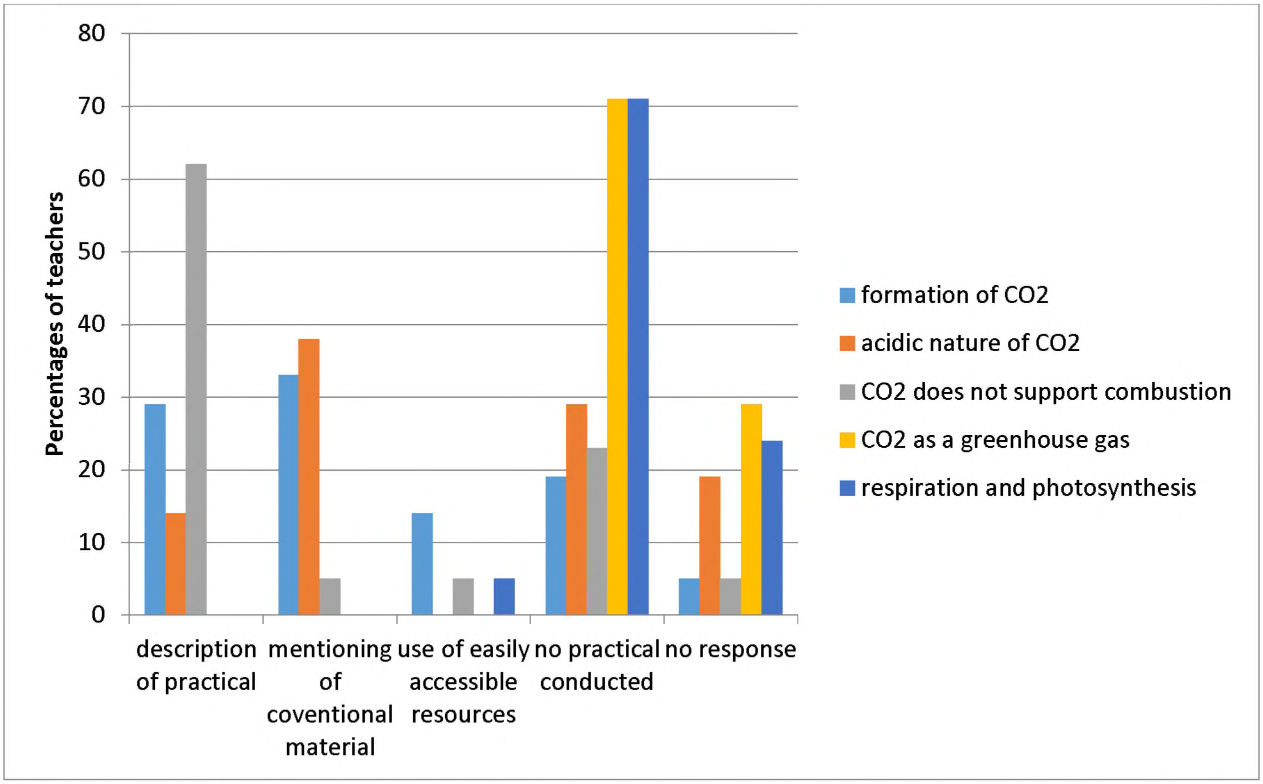

FIGURE 1: TEACHERS' RESPONSES TO ASSESSMENT OF THEIR EXPERIENCES OF BEING TAUGHT THE TOPIC

On the practical activity on how carbon dioxide gas is formed, out of 21 participants, 6 (29 %) described practical activities using conventional chemicals and apparatus. Seven participants (33%) mentioned conventional chemicals or apparatus by way of stating or listing without giving a description of a practical activity conducted. Three participants (14%) mentioned the use of easily accessible resources. Four participants (19%) indicated that they did not have this practical activity. One participant (5%) did not respond. With regard to the practical activity on the acidic nature of carbon dioxide gas, out of 21 participants, 3 (14 %) described practical activities using conventional chemicals and apparatus. Eight participants (38%) mentioned conventional chemicals or apparatus by way of stating or listing without giving a description of a practical activity conducted. Six participants (29%) indicated that they did not have this practical activity. Four participants (19%) did not respond.

On the practical activity on carbon dioxide does not support combustion, out of 21 participants, 13 (62%) described practical activities using conventional chemicals and apparatus. One participant (5%) mentioned conventional chemicals or apparatus by way of stating or listing without giving a description of a practical activity conducted. One participant (5%) mentioned the use of easily accessible resources. Five participants (23%) indicated that did not have this practical activity. One participant (5%) did not respond.

When it comes to the practical activity on carbon dioxide as a greenhouse gas, it emerged that 15 participants (71%) had not experienced a practical activity of this kind and 6 (29%) did not respond to this question.

The last practical activity question about the processes of respiration and photosynthesis, one participant (5%) mentioned the use of easily accessible resources. Fifteen participants (71%) had not had any practical activity while 5 participants (24%) did not respond.

4.3.2 Experiences of teaching the topic

The second question on the questionnaire asked participants to describe their experiences of teaching the topic on carbon dioxide gas. This was aimed at establishing the participants' experiences of doing practical activities in their science classrooms (research sub-question 1). Their responses are summarised in Table 10 and Figure 2.

TABLE 10: EXPERIENCES OF TEACHING THE TOPIC ON CARBON DIOXIDE GAS IN THE SCIENCE CLASSROOM

Practical activities	**Description of practical and conventional chemicals/ apparatus**	**Mentioning of conventional chemicals/apparatus without description of practical**	**Use of alternative (easily accessible) resources to do practical**	**No practical done**	**No responses**	**No experience in teaching the topic**
Practical on formation of carbon dioxide	T1M, T2M, T3M, T4M, T5M, T7F, T9F, T10F, T14M	None	T8M	T11F	T13M, T15M, T16M, T18, T20F, T21M	T6M, T12M, T17F, T19F

Practical on acidic nature of carbon dioxide	T1M, T2M, T3M, T4M, T5M	T6M, T9F, T10F	None	T12M, T14M, T17F	T8M, T15M, T16M, T18F, T19F, T20F, T21M	T7F, T11F, T13M
Practical on CO_2 does not support combustion	T1M, T2M, T3M, T4M, T5M, T6M, T7F, T9F, T10F, T14M	T8M, T19F	None	None	T13M, T15M, T16M, T18F, T20F, T21M	T11F, T12M, T17F
Practical on CO_2 is a greenhouse gas	None	None	T19F	T1M, T2M, T4M, T5M, T6M, T7F, T9F, T11F, T14M,	T3M, T8M, T10M, T13M, T15M, T16M, T18F, T20F, T21M	T12M, T17F
Practical on respiration and photosynthesis in nature	None	None	None	T1M, T2M,T3M, T4M, T5M, T6M, T7F, T9F, T11F, T14M, T19F	T8F, T10M, T13M, T15M, T16M, T18F, T20F, T21M	T12M, T17F

Figure 2 shows a graph of the data which is based on the responses summarized in Table 10.

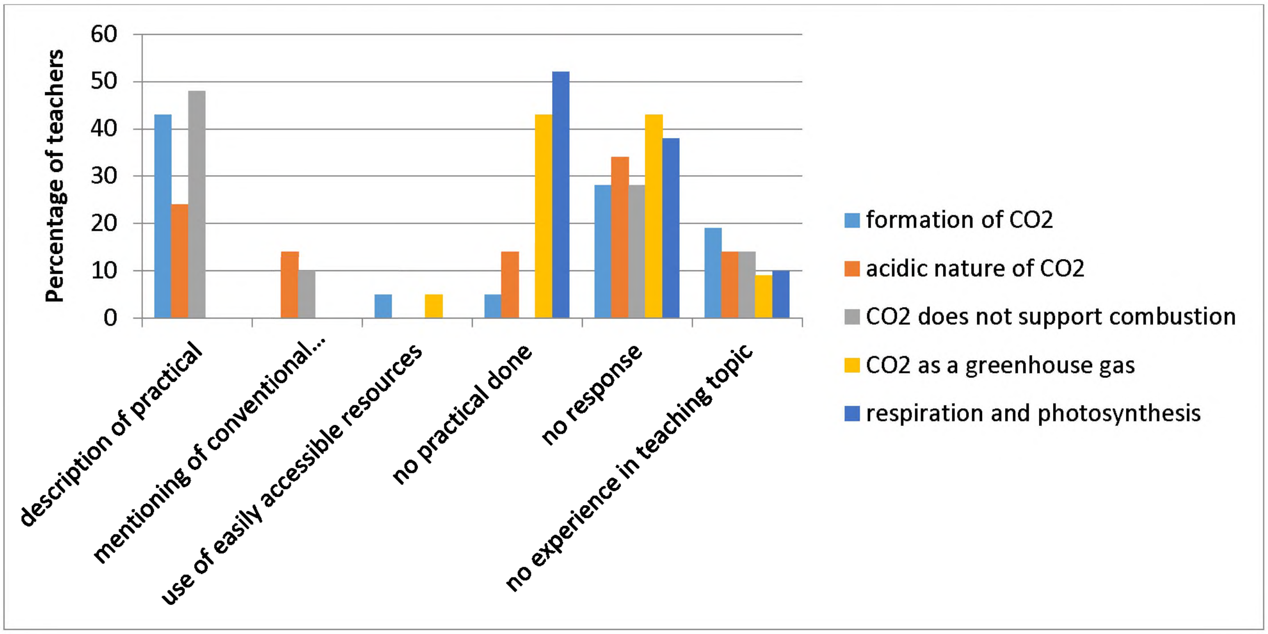

FIGURE 2: TEACHERS' RESPONSES TO ITEMS ASSESSING THEIR EXPERIENCES OF TEACHING THE TOPIC

The responses to the question on practical activities regarding the formation of carbon dioxide reveal that 9 participants (43%) described a practical activity using conventional chemicals or apparatus. One participant (5%) mentioned the use of easily accessible resources and another one participant (5%) has not conducted this practical activity. Six participants (29%) did not responded to this question and 4 (19%) indicated that they have no experience in teaching this topic.

Regarding the practical activity on the acidic nature of carbon dioxide, 5 participants (24%) described the practical activity using conventional science apparatus and equipment. Three participants (14%) mentioned conventional materials/apparatus without describing the practical activity. Another three participants (14%) have not done the practical activity. Seven participants (33%) did not respond to this question and 3 (14%) indicated that they have no experience in teaching this concept.

On the practical activity of carbon dioxide does not support combustion, 10 participants (48%) described the practical activity using conventional apparatus/chemicals. Two participants (9%) only mentioned conventional materials without description of practical activities. Six participants

(29%) did not respond to this question and 3 (14%) indicated that they have no experience in teaching this topic.

With regard to the practical activity on carbon dioxide as a greenhouse gas, one participant (5%) mentioned the use of easily accessible resources. Nine participants (43%) indicated that they have not done this practical activity. Another 9 % (43%) did not respond to this question and 2 (9%) have no experience in teaching this aspect.

The last practical activity on carbon dioxide, the processes of respiration and photosynthesis, 11 participants (52%) have not done this practical activity, 8 (38%) did not respond to this question and 2 (10%) indicated that they do not have experience in teaching this topic.

4.3.3 Enabling and constraining factors

The third question on the questionnaire required participants to express what factors enable or constrain them in teaching the topic on carbon dioxide. This was aimed at gaining further insight into the factors which influence the experiences of the participants with regard to doing practical activities in their classrooms (research sub-question 2).

4.3.3.1 Factors which enable their teaching

The factors which enable participants to teach the topic on carbon dioxide are summarised in Table 11.

TABLE 11: FACTORS WHICH ENABLE TEACHING THE TOPIC ON FORMATION OF CARBON DIOXIDE

Enabling factors	Participants
Availability of materials	T1M, T3M, T5M, T9F, T13M,
Improvisation	T2M, T7F
Textbooks	T6M
Prior knowledge	T3M, T4M, T12M, T13M, T14M
No response	T8M, T15M, T16M, T18F, T20F, T21
No experience	T17F, T19F
No need to do practical	T10F

The responses from Table 11 are presented in Figure 3 below.

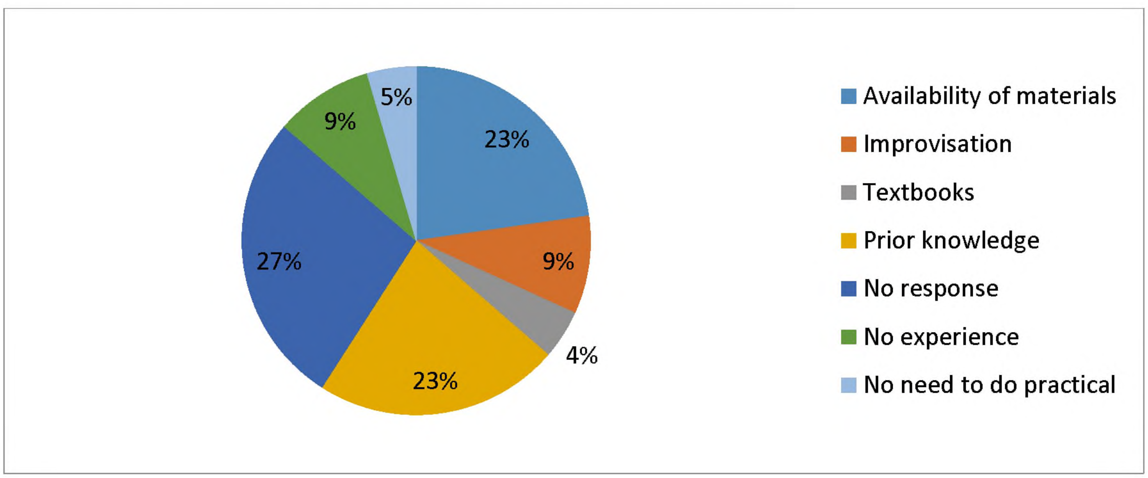

FIGURE 3: FACTORS WHICH ENABLE TEACHING THE TOPIC ON FORMATION OF CARBON DIOXIDE

The dominating two factors from the data are the availability of materials and the prior knowledge on the materials to be used. This emerged from 10 participant altogether making up a percentage of 46%. Two participants mentioned improvisation (9%) and one mentioned textbooks (4%). One participant mentioned that there is no need to do practical activities (5%) and two mentioned that they did not have any experience to do so (9%). The remaining 6 participants (27%) did not respond to this question.

4.3.3.2 Constraining factors

The factors which constrain the participants to teach the topic on carbon dioxide are summarized in Table 12.

TABLE 12: FACTORS WHICH CONSTRAIN TEACHING THE TOPIC ON FORMATION OF CARBON DIOXIDE

Constraining factors	Participants
Unavailability of chemical/apparatus	T2M, T6M, T9F, T11F, T12M, T13M, T17F, T19F
Unavailability of school laboratories	T5M, T6M, T7F, T10F
Abstract nature of the gas (invisible)	T3M, T4M
Lack of creativity to use local materials	T9F
Time constraints	T1M, T9F
No response	T14M, T15M, T16M, T18F, T20F, T21M

The responses from Table 12 are presented in Figure 4 below.

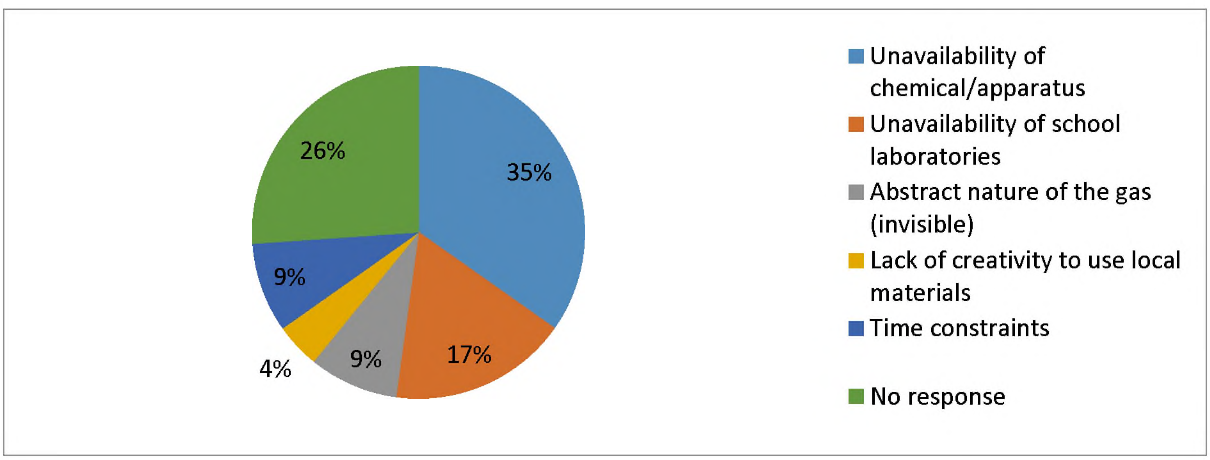

FIGURE 4: FACTORS WHICH ENABLE TEACHING THE TOPIC ON FORMATION OF CARBON DIOXIDE

It emerged from the data that the dominating constraining factor is the unavailability of materials (chemicals and apparatus) as well as the unavailability of school laboratories. This data emerged from the majority of the participants (12), making up a percentage of 52%. Two participants (9%) mentioned the abstract nature of the gas and another two participants (9%) mentioned time constraints. The remaining 6 participants (26%) did not respond to this question

4.4 Discussion of quantitative results

In the next sections, I discuss the quantitative results in terms of experiences from studies, teaching experiences, enabling factors and constraining factors.

4.4.1 Experiences from studies

From this data, it emerged that in cases where practical activities were conducted by teachers, they made use of conventional chemicals and materials to carry them out. In most cases, the teachers were taught the topic either at school or college/university without practical activities having been conducted. In a few cases there was mention of the use of easily accessible resources. This is in line with the observations of Kasanda, et al. (2005) who recommended that teacher training programs need to pay more attention to preparing teachers to teach in a LCE manner such as preparing them to be able to conduct practical activities drawing on everyday contexts It is also in line with the ideas of Ogunniyi and Ogawa (2008) who advised that tertiary institutions are required to produce skilled personnel who are able to embrace and incorporate IK in their teaching and learning processes.

4.4.2 Experiences of teaching practical activities

From this data, it emerged that a handful of participants (ranging from 2-4) indicated that they have no experience in teaching the practical activities from one to all five examples listed in the questionnaire. According to the biographical information (see Table 8), only teachers T20F and T21M currently teach Mathematics only. The rest of the teachers (teachers 1-10) currently teach Physical Science whilst teachers 11 to 19 currently teach either Natural Science, Life Science, Biology or Agriculture. For instance, participants T12M and T17F have indicated that they have no experience in teaching 4 out of 5 of the examples of practical activities given in the questionnaire. However, these activities are part of the category of the subjects Natural Science, Life Science, Biology and Agriculture where the topic formation of carbon dioxide is taught. Also, participant T17F indicated that she has teaching experience of 1-5 years in Physical Science. I have picked up some contradictions in the responses because the teachers who indicated that they do not have experience in teaching these practical activities are in fact teaching the subjects in which these topics are taught.

The majority (on average 12 teachers per practical activity) of teachers indicated that they have either not done a practical activity or they have not responded at all. A few teachers (on average 5 teachers per practical activity) have done practical activities on a few of the concepts but only using conventional chemicals. Only two teachers mentioned the use of alternative resources and in these cases, they used them on two out of five practical activities which were asked about, giving an overall representation of about 8%.

In the light of the above, Oloruntegbe and Ikpe (2011) highlighted that teachers need to be trained on how to improve the use of students' home experiences in such a way that students will clearly see the connections between the home experiences and school science.

4.4.3 Factors which enable their teaching

The dominating enabling factor which emerged from this data is that the availability of materials and prior knowledge about the materials would enable teachers to conduct practical activities in their science classrooms. Two participants (9%) indicated that improvisation would enable them to carry out practical activities. One teacher (5%) indicated that there is no need to do practical activities (this is unusual because this is a Physical Science teacher, T10F).

4.4.4 Factors which constrain their teaching

It also emerged from this data that the main constraining factors in conducting practical activities in their lessons is the lack of chemicals and the unavailability of laboratories in the schools. Shulman (1986, 1987) points out that for teachers to be able to incorporate the use of available resources in their contexts in their teaching, they should have knowledge of the resources.

4.5 Concluding remarks

This chapter began with a presentation of the quantitative results for Phase 1 which were gathered using questionnaires as a data gathering tool. From these results, it was clear that the majority of the teachers did not have any exposure to the use of easily accessible resources to carry out hands-on practical activities in their science classrooms. This emerged from the responses to the questions which required them to indicate both how they were taught and how they teach the concepts on formation of carbon dioxide gas. This information answered research sub-questions 1 and 2 which sought to probe the experiences of science teachers regarding practical activities in their science classrooms as well as the factors that affect their experiences. The findings from Phase 1 informed the preparation of the intervention in the form of a workshop using easily accessible resources to carry out hands-on practical activities which was the focus of Phase 2.

In the next chapter, I present, analyse and discuss data for Phase 2, which is the intervention in the form of a workshop on using easily accessible resources to carry out hands-on practical activities in science.

CHAPTER 5: DATA PRESENTATION, ANALYSIS AND DISCUSSION (PHASE 2)

5.1 Introduction

In this chapter, I present, analyse and discuss data gathered from Phase 2. As described in Section 3.5.3.1, in Phase 2, my co-researcher and I carried out an intervention in the form of a workshop which took place over a period of one week. The research participants for Phase 2 are the same teachers who participated in Phase 1 (see Section 4.2 and Table 8). During the intervention, data were gathered by means of observations, semi-structured interviews and reflections (see Table 4). The data for Phase 2 was aimed at answering my research sub-question 3 which is:

> How does an intervention on the use of easily accessible resources to carry out hands-on practical activities in the science classroom influence science teachers' conceptual development and dispositions towards practical activities in science?

In this chapter, I present firstly the quantitative results based on the reflections written by the participants at the end of the workshop. This is followed by the qualitative results from observations, reflections and semi-structured interviews. The chapter ends with some concluding remarks.

5.2 Quantitative results

At the end of the intervention in the form of a workshop, teachers were given an opportunity to reflect on their experiences of the workshop. In the next sub-sections, quantitative data from these reflections is presented in terms of past experiences of the participants regarding the activities which were carried out during the workshop. In addition, quantitative data is also presented in terms of how the workshop has positively influenced the participants' views and attitudes towards the use of easily accessible resources to carry out practical activities.

5.2.1 Past experiences on activities done during the intervention

On the reflection guide (see Appendix E), participants were asked to indicate whether they had any previous exposure to the practical activities which were carried out during the workshop. The data are presented in Figure 5.

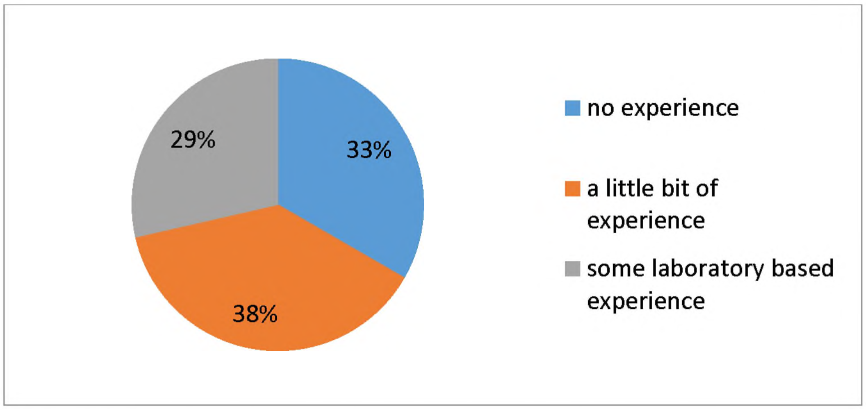

FIGURE 5: PAST EXPERIENCES ON ACTIVITIES CONDUCTED DURING THE WORKSHOP

The graph reveals that 7 out of 21 participants (33%) had no past experience regarding the activities which were conducted during the workshop. Eight participants (38) indicated that they had some experience of a few of the activities. Six participants (29%) indicated that they only had a laboratory based experience. This information resonates with the findings of Phase 1 (see Sections 4.3.1 and 4.3.2) where it emerged that the participants had mainly laboratory based experiences on practical activities and some had no experience in using practical activities as described in the examples in the questionnaire.

5.2.2 Influence of workshop on participants' attitude towards practical activities

One of the questions on the reflection guide (see Appendix E) required participants to indicate whether participation in the workshop had influenced the participants' attitude towards practical activities or not. The data is presented in Figure 6.

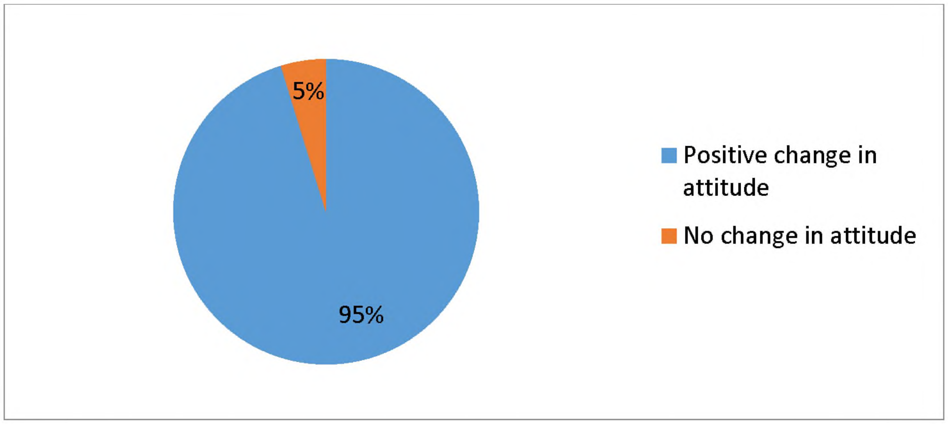

FIGURE 6: INFLUENCE OF THE WORKSHOP ACTIVITIES ON THE PARTICIPANTS' ATTITUDE TOWARDS PRACTICAL ACTIVITIES

The data from Figure 6 reveals that 20 out of 21 participants (95%) indicated that the workshop had a positive influenced on their attitude. The remaining one participant indicated that the workshop did not change his attitude towards practical activities as he already had a positive attitude before the workshop as reflected in the comment below.

> *"No. I always believed that practical work is an important task of science learning. It was just a confirmation of my idea"* (RT10).

5.2.3 Discussion of quantitative results

These findings (Figure 5) resonate with the findings of Phase 1 (Figures 1 and 2) where the majority of the participants indicated that they did not have sufficient exposure to practical activities or they had mainly laboratory based exposure. Jung and Rhodes (2008) affirm that the dispositions of people can be changed through educational experiences. Ogunniyi and Hewson (2008) found that after a six months' exposure to an argumentation based course, teachers were more willing to accept IKS as a potentially legitimate aspect of the science curriculum. Hanisi (2006) also indicates that she developed the interest and curiosity to use *Umqombothi* in Life Sciences to teach alcoholic fermentation after she participated in a science education module which involved the science of fermentation.

5.3 Qualitative results

The data from reflections of teachers (RT1 to RT21), observations (OB1 to OB3) and semi-structured interviews (IT1F, IT2M, IT3F) were analysed. Firstly, the data was colour coded in order to generate sub-themes which are related to my research sub-question 3 as well as to the literature discussed earlier.

Table 13 shows the sub-themes that emerged from the qualitative data.

These sub-themes are aimed at answering my research sub-question 3 which is:

> How does an intervention on the use of easily accessible resources to carry out hands-on practical activities in the science classroom influence science teachers' conceptual development and dispositions towards practical activities in science?

TABLE 13: PRELIMINARY SUB-THEMES FROM CODES

Code	Description of marked text	Sub-themes
RT1, RT2 RT8, RT9 RT11, RT13 RT18, RT20 RT21, RT22 RT23	Understand the lessons well; understand and internalize; move away from memorizing facts; allows all learners to come along; make learning more meaningful, help them to learn science; help our learners to understand better; help learners of different learning needs; ensure effective learning, practical activities enhance learning and understanding.	Learning with understanding
RT1; RT2 RT11; RT14 RT16	Understand through observation; observing and prove at some point to how observation allows me to prove; confirm their assumption observe using their sense organs; visualization of science	Observations for evidence
RT2, RT7 RT8, RT14 RT16 RT19	Shows how real are the concepts written in our syllabus; materials learners are familiar with; help learners to create a bridge between their home sciences understand that science is around them; contextualize their knowledge learners are used for them and get in touch with them bring the reality into the classroom	Links to real life/context
OB1; OB2 OB3	Fermentation, Respiration; Aerobic; Anaerobic	Emerging scientific concepts

IT2M, IT3F RT1, RT3, RT4, RT5, RT6, RT12, RT13	Easily accessible alternatives no chemicals and science apparatus in remote areas	Unavailability of chemicals/equipm ent as excuses
IT1F; IT3F RT4; RT6 RT8; RT13 RT17; RT19 RT21	It is cheap and; cost efficient, It is more cheaper as the resources/ materials they are of affordable price; it is not costly it is cheap; bought at a cheaper price	Cost of resources
IT3F; RT6 RT7; RT8 RT9; RT10 RT13; RT16 RT19; RT21	It uses readily available resources can be generated from the environment we have access to all the resources they are easy to get as some of them they are using them at home	Availability of resources
IT1F; IT3F RT6; RT10	We have less knowledge on how to access resources within our reach teachers are unaware of those simple experiments we can carry out	Knowledge of resources
RT2, RT3, RT6, RT7 RT11; RT12 RT14; RT16 RT19; RT20 RT21	It helped us engage with our thinking abilities predict helps learners to recall what they have already learned time to think about the aspect; It gives room for students to think, think critical to what will happen; think critically; probes critical thinking; we had a chance to think for ourselves mentally enriching activities	Stimulates questions and thinking
IT3F; RT4 RT7; RT8 RT16;RT18,	Captures learners' interest; encourage active participation Learners feel involved in the learning process. It make learners take ownership of their learning; fun makes learning interesting; it is really interesting makes the lesson interesting; get the taste of science interesting to the learners	Captures interest
RT1; RT4 RT7; RT9	It motivate learners to participate and learn from context to content, encourage active participation; helping learners to be engaged fully in the lesson it makes the classroom live, learners engaged well	Active participation
IT1F, IT3F RT1, RT2 RT3, RT5 RT6,RT11 RT12	Yes it changed my attitude towards practical activities I am more encouraged to engage in practical activities I think I have to change my teaching strategy of conducting practical activities.	change in attitude towards practical activities
IT1F; IT3F RT2; RT5 RT9; RT11 RT14 RT20	I will share my knowledge with fellow science teachers these activities should be carried out with other science teachers I am even planning to do this to my teachers in my circuit. other teachers should be trained bring up more practical activities during the next session	Attitude towards professional development

I then combined common sub-themes to form themes and in relation to theory/literature as showed in Table 14. These themes are aimed at answering research sub-question 3 which is:

TABLE 14: THEMES AND SUPPORTING THEORY/LITERATURE

Themes	Theory/Literature
Theme 1: Learning with understanding	
Learning with understanding Links to real life Observations for evidence Emerging scientific concepts	Roschelle (1995); Johnstone (2010); Stears, Malcolm and Kowlas (2003); Kuhlane (2011); Oloruntegbe and Ikpe (2011); Mukwambo, Ngcoza and Chikunda (2014); Kibirige and van Rooyen (2006);Gott and Duggan (1996); Woodley (2009); Abrahams and Millar (2008); Shifafure (2014); Leach and Scott (2003)
Theme 2 Knowledge of resources	
Perceptions on unavailability of resources; awareness of potential of resources; Costs of resources Availability of resources	Lave and Wenger (1991); Shulman (1986, 1987) Aikenhead and Jegede (1999);Van Driel (2010)
Theme 3 Interest and participation	
Stimulates questions and thinking Captures interest Active participation	Hodson (1990);Maselwa and Ngcoza (2003); Jokiranta (2014); O'Donoghue, Lotz-Sisitka, Asafo-Adjei, Kota and Hanisi (2007); Klein (2011) Erinosho (2013)
Theme 4 Continuous professional development	
Change in attitude towards practical activities Attitude towards professional development	Jung and Rhodes (2008); Ogunniyi and Hewson (2008); Hanisi (2006); Atallah, Bryant and Dada (2010); Mizell (2010); Harwell (2003); Ogunniyi and Ogawa (2008); Shizha (2007); Ngcoza (2007)

5.4 Conceptual development and disposition of teachers

As outlined in Section 3.2.4, during Phase 2, my co-researcher and I conducted a workshop. This workshop was conducted for a period of 5 days as explained in Section 3.5.3.1. We made use of observations, semi-structured interviews and reflections to gather data as stated in Table 4. Nine hands-on practical activities using easily accessible resources were carried out during the workshop as summarised in Table 5. These activities were informed by the data gathered during Phase 1 as mentioned in Sections 3.2.3 and 4.5.

I now discuss each of these themes below highlighted in Table 14.

5.4.1 Learning with understanding

The participants shared in the variety of hands-on practical activities citing that they enhanced learning with understanding, made links to real life, enhanced observation for evidence and enabled them to come up with scientific concepts. For example, four teachers reflected that:

> "*I have realized that I rob my learners to understand the lessons well where they were supposed to fully understand through observation and have longer understanding*" (RT1).
>
> "*Doing practical activities helps learners to understand and internalize what they are being taught. It helps them to move away from memorizing facts rather than observing and prove at some point to how true or how real are the concepts written in our syllabus*" (RT2).
>
> "*It is a powerful form of doing practical activities because it allows learners to get to understand that science is around them*" (RT16).
>
> "*I feel practical activities should really be reinforced in classrooms. I feel that they make learning more meaningful and fun*" (RT18).

Also, since the participants worked in groups during the practical activities, they were able to come up with scientific concepts in relation to the practical activities they were engaged in. For instance, from the practical activity on the preparation of *Ontaku/Oshikundu* (the Oshiwambo traditionally brewed beverage). The various groups were able to come up with the different concepts as shown in Figure 7.

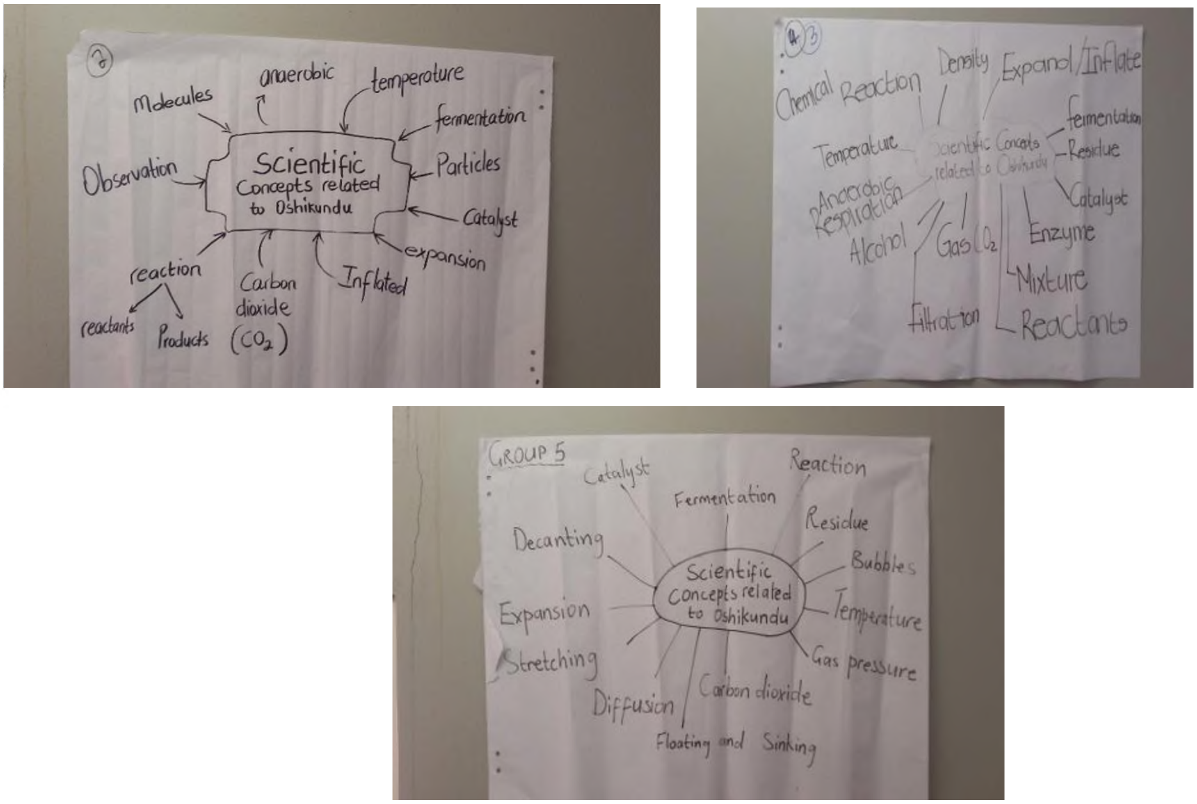

FIGURE 7: MIND MAPS ON ONTAKU/OSHIKUNDU PRACTICAL ACTIVITIES

All five groups managed to come up with different scientific concepts. Table 15 shows collated scientific concepts which emerged from the mind maps of the five groups.

TABLE 15: CONCEPTS WHICH EMERGED FROM THE ONTAKU/OSHIKUNDU PRACTICAL ACTIVITY

Group 1	Group 2	Group 3	Group 4	Group 5
Synthesis Energy Catalyst Glucose CO_2 Floating Fermentation Alcohol H_2O	Molecules Anaerobic Temperature Fermentation Particles Catalyst Expansion Inflated	Chemical reaction Density Expand Inflate Fermentation Residue Catalyst Enzyme	Alcohol Product Enzymes Biological catalyst Carbon dioxide Anaerobic respiration Reactants Fermentation	Decanting Fermentation Reaction Residue Bubbles Temperature Gas pressure Carbon dioxide Floating

	Carbon dioxide (CO_2) Reaction Reactants Products Observation	Mixture Reactants Gas CO_2 Filtration Alcohol Anaerobic Respiration Temperature	Expansion Inflation	Sinking Diffusion Stretching Expansion Catalyst

Figure 8 shows a set-up of the *Oshiwambo* traditionally brewed beverage called *Oshikundu or Ontaku*.

FIGURE 8: DIFFERENT SAMPLES OF ONTAKU/OSHIKUNDU

Figure 9 shows students preparing the practical activity on uncooked eggs placed in different liquids such vinegar, Coca-Cola, lemon juice and distilled water (see Table 5).

FIGURE 9: PREPARATION OF UNCOOKED EGGS IN DIFFERENT LIQUIDS

These insights from the participants' reflections indicate that the variety of activities conducted during the workshop influenced participants' conceptual development and disposition towards the use of practical activities in the science classroom. Roschelle (1995) affirms that learning proceeds predominantly from prior knowledge. This is in line with the fact that the activities which were used in this workshop were familiar materials from the participants' everyday life and in turn resulted in emerging science concepts. In line with this, Stears, et al. (2003) emphasizes that learners relate strongly to content that relates to their lives, as it was the case with the materials used in this workshop.

Johnstone (2010) states that chemistry should be presented in a way that capitalises on what learners are familiar with, and indeed the materials which were used during the workshop were those that participants were familiar with. These ideas are supported by Mukwambo, et al. (2014) who report that the inclusion of IK promotes teaching and learning scenarios in which both teachers and learners engage in knowledge construction and the fact that participants were able to come up with scientific concepts emerging from the activities showed that these participants were involved in knowledge construction. Stears, et al. (2003) also express that learners relate strongly to content that deals with the fact of their lives. Kibirige and van Rooyen also (2006) agree that science teaching is enriched when IK is used as indigenous prior knowledge in the classroom and can thus be used as a starting point to explore concepts associated with WS. Similarly, Uushona (2012) used indigenous fruit to make a traditional liquor called *Ombike* through the process of fermentation and distillation. In Uushona's study, it emerged that conceptual understanding and sense making were enhanced. Shifafure (2014) too, conducted a study using *Kashipembe*, a traditional beverage used in Kavango. His findings echo those of Kambeyo (2012), Klein (2011), and Uushona (2012). The findings of these studies resonate well with the finding of my study.

Gott and Duggan (1996) express that practical activities have a key role in teaching evidence in science. Effective practical activities enable learners to make links between theory and practice, ensuring that the students are able to apply their scientific understanding to the real world application of science (Millar, 2010; Woodley, 2009). This was also evident from the data that participants were able to make links to their everyday lives and were able to observe the evidence of the theoretical concepts of science.

These findings are also in line with the findings of a number of South African science teachers who have also conducted case studies using easily accessible resources to conduct practical activities in the science classrooms (e.g. Kuhlane, 2011; Maselwa & Ngcoza, 2003; O'Donoghue, et al, 2007). To this end, Maselwa and Ngcoza used easily accessible resources such as old transparencies in their study on practical activities in electrostatics in Physical Science. Asafo-Adjei (2004), an Agricultural Science teacher looked at changing wild vegetables (*imifino*) to cultivated vegetables (*umfuno*). Hanisi (2006) used an indigenous fermented beverage called *Umqombothi* in Life Science to teach the concept of fermentation.

5.4.2 Knowledge of the resources

Most participants commented on their knowledge of resources stating that there is a strong perception among teachers that they do not conduct practical activities because of the lack or unavailability of resources and laboratories. The following are some of the comments from the participants' reflections.

> "*Because most teachers do not conduct practical simply because they do not have laboratory and apparatus*" (RT1)
>
> "*Many of us (teachers) fail to expose our learners to these activities claiming that there are no laboratories or chemicals at school*" (RT5).
>
> "*…now I can able to prepare practical activities even if the school does not have a science lab or the lab is not equipped*" (RT4).
>
> "*And moreover, we have less knowledge on how to access resources within our reach*" (RT6).
>
> "*It encourage me/gave me insight that although there is no lab at school, I can still use available/cheap materials at home/shops to do practical activities*" (RT9).
>
> "*We have access to all the resources. It is only that we really do not know how to use them in terms of performing practical activities using such resources. Yes because teachers are unaware of those simple experiments we can carry out*" (RT10).

The following are excerpts from the semi-structured interviews.

> "*Now I am remembering now the activity that we have done that one for caustic soda and the Magnesium, I mean the Aluminium foil... I didn't know that Aluminium can react like that*" (IT1F).
>
> "*This is wonderful for everyday material because at tertiary education, you are being taught to go and teach at different schools, and if you are only taught using regular materials, those materials you may not be having them at your school so using everyday material it helps you to prepare the gases like the one we were testing or to, it helps you to carry out different investigations regardless of the availability or unavailability*" (IT2M).
>
> "*Some of the things are the things that I even have at home, every day I see them some of them I deal with them, I eat them, eggs and Oshikundu things I drink them but then the way you put them up in the way of activities it was really something else for me ... but now I never just thought of using a weak acid, or even a strong acid to look at now how the egg is being reacting with the acid ... the foil, I used it, I threw it away, I know it is a metal, I talk about it that aluminium can be used for making food containers, foil is one of the examples, but then I never came to an example or idea of taking it as a metal, reacting it with something to produce that hydrogen…* (IT3F).

The participants acknowledged that most of the materials used in the workshop are readily available, within their reach and are affordable. This is demonstrated by the flowing quotes:

> "*Also, it is cheaper as the resources/materials to be used in the practical activities can be generated from the environment*" (RT8).
>
> "*Yes because we use to give excuses that there are no equipment at school but now I have an idea that you can get them in shops at a cheaper price or use local materials*" (RT13).
>
> "*…materials or resources does not cost too much to buy them*" (RT17).

These findings support the literature (Shulman; 1986, 1987) that suggests that in order for teachers to use resources, they must have knowledge of the resources. For instance, Shulman (1986, 1987) states that in order for teachers to be able to effectively mediate learning, they should know the best strategies to employ in order to make the content easily accessible to the learners. Aikenhead and Jegede (1999) reinforce that teachers need to develop culturally sensitive teaching methods that reduce the foreignness felt by the learners in order to ensure a smooth transition between the learners' everyday knowledge and the science taught in schools. Concurring, Van Driel (2010) posits that a teacher should be able to use resources that are available in the local environments of the learners and that learners are familiar with.

Hewson (1992) states that for effective teaching of science, it is the teacher's responsibility to engage in teaching practices that facilitates conceptual change to occur. Conceptual development is more likely to take place if the planned activities are relevant to the context (Leach & Scott, 2003). This relates to knowledge of resources that in order for a teacher to use familiar teaching resources, the teacher needs to have the knowledge of those resources.

5.4.3 Interest and participation

The participants commented on the influence of the hands-on practical activities on their interest and participation. They stated that the activities captured their interest, stimulated questioning and thinking and enhanced active participation. These ideas are supported by these quotes:

> "*This was a great approach that I could not even use or think of during my teaching. It helped us engage with our thinking abilities*" (RT2).

"*It was an excellent way of teaching learners taught in this way would be given time to think about the aspect/concept before the experiment is done*" (RT6).

"*It promotes learning and encourages active participation because learners are dealing with materials they are familiar with*" (RT7).

"*The approach was good because we had a chance to think for ourselves*" (RT19).

"*Yes because they are quite mentally enriching activities*" (RT21).

"*It makes learning interesting and seems simple by the learners*" (RT22).

"*….it is very enjoyable, the way I was myself in that workshop I could put myself as a learner…it was an exciting moment for me already… So already, even if I know it, it was very exciting moment for me just to test that hydrogen coming from the foil, that I know about, that I see it coming from my kitchen*" (IT3F).

These excerpts echo the views of Hodson (1990) who state that hands-on practical activities are an enjoyable exercise that promote understanding. Furthermore, these insights agree with the findings of Maselwa and Ngcoza (2003) who posit that practical activities encourage active participation by making learners experience science first hand and are an effective form of learning. In Erinosho's (2013) Nigerian case study, it emerged that learners were excited to engage in hands-on practical activities as they were able to find relevance in what they studied in their classrooms to their local contexts. Similarly, in Ngcoza, et al.'s (2016) South African case study, it emerged that learners who participated in science expos become more motivated to study science at school. This is also in line with the sociocultural theory of Vygotsky (1978) which emphasises the importance of context in teaching and learning, leading to meaningful learning as individuals operate in social contexts that engage with cultural products which are made available to them in their contexts (Jaworski, 1993; Leach & Scott, 2003; Turuk, 2008).

5.4.4 Continuous Professional Development

The participants developed a positive attitude towards use of practical activities in their science classrooms. They indicated that they enjoyed the practical activities and that they felt confident to implement the activities in their classrooms. The following excepts reflect the participants' positive attitude towards practical activities.

> "*Yes it changed my attitude towards practical activities in the way that I have to take practical activities seriously because it makes the classroom live, learners engaged well in the lessons and practical make it perfect. Learners learn well by doing*" (RT1).

> "*Yes it make me realize how practical activities helps learning and retention of information to the learners. It will help learners to master and link concepts and develop them too*" (RT2).

> *"Yes, I got to learn that as a teacher I have to involve learners in practical activity. I learn that practical activities is important and it can help learners to have a broad understanding of new concepts"* (RT3).

These three participants highlight above that their attitude towards practical activity has changed radically because they have realised that practical activities help learners to understand better and develop scientific concepts.

Similarly, the following participants demonstrated a constructive attitude when they pointed out that one is able to carry out practical activities even if the school does not have a laboratory or conventional material and equipment.

> "*Yes, now I can able to prepare practical activities even if the school does not have a science lab or the lab is not equipped*" (RT4).

> "*Yes, it is because all along I use to think that practical activities can be only done in the lab, (fully equipped one). But now I developed an attitude that I can use available resources in the environment and do practical activities*" (RT9).

This participant indicated that the practical activities conducted during the workshop were most enjoyable:

> "*Yes some of the practical I have done them during my teaching, but not as nicely as it was done during the week*" (RT5).

In addition to an enjoyment of activities, this participant revealed that 'time should not really be a hindrance to conducting practical activities.

> "*I am more encouraged to engage in practical activities. I also realized that the aspect of TIME does not really have to be a factor. Because in fact the learning you are trying/rushing to teach via theory is actually taking place during practical activity*" (RT6).

This participant made an interesting remark stating that his/her belief towards practical activities had shifted because he/she never believed learners could learn during practical activities.

> "*I am that teacher that does not believe in practical activities, with the experience that learners do not learn anything. Now I am rethinking my teaching approach. I think I have to change my teaching strategy of conducting practical activities*" (RT12).

The participants also demonstrated a change in disposition towards continuous professional development because they recommended that these activities should be carried out with other science teachers in Namibia. The following are some excerpts from the participants' reflections.

> "*I highly recommend that these activities should be carried out with other science teachers to that it helps them realize the importance of practical activities to both learners and teachers*" (RT2).
>
> "*Yes all the science teachers needs to conduct the practical activities because science is more about practice*" (RT11).
>
> "*Yes, thanks for entitling us to instilling a positive attitude towards the use of practical activities using easily accessible resources*" (RT20).

These reflections revealed that the participants were in favour of professional development activities being conducted with other teachers in Namibia.

Atallah, et al. (2010) indicated that real life experiences promote interest and confidence, such as the participation in these hands-on activities. This is in line with the explanation offered by Jung and Rhodes (2010) that the disposition of people can be changed through educational experiences. These findings are supported by Ogunniyi and Hewson (2008) and Hanisi (2006) as described above. Mizell (2010) affirms that professional development can happen during formal processes such as a workshop and that it is not an event, it is part of a process. Many of the problems facing science teaching and learning today could be resolved through professional development (Ngcoza, 2007; Ogunniyi & Ogawa, 2008; Shizha, 2007).

5.5 Concluding remarks

This chapter began with the presentation of quantitative and qualitative data for Phase 2. These were data from the reflections of participants, semi-structured interviews as well as observations. It was evident from the data that the majority of the participants did not have sufficient exposure to the use of easily accessible resources to carry out hands-on practical activities in their classrooms. The reflections showed that their attitude towards conducting practical activities using easily accessible resources changed dramatically after they participated in the workshop. It was also evident that the participants recommended that this type of workshops should be conducted with other teachers in Namibia. Four main themes emerged from the data. That is, hands-on practical activities enhance learning with understanding where links are made to real life through observation of evidence and conceptual development. Another theme which emerged concerned the knowledge of the resources that teachers need to have in order to identify easily accessible resources which they could employ in their classrooms. Another theme highlighted the increased interest and involvement as a result of participating in the workshop and lastly the increase in a positive attitude towards continuous professional development.

In the next chapter, I present, analyse and discuss the data from Phase 3.

CHAPTER 6: DATA PRESENTATION, ANALYSIS AND DISCUSSION (PHASE 3)

6.1 Introduction

This chapter summarises the results of the data collection of Phase 3 (see Section 3.2.5) in which I observed two teachers teaching hands-on practical activities using easily accessible resources. As explained in earlier chapters, in this study the first phase looked at the experiences of teachers regarding practical activities in the science classroom (see Sections 3.2.3 and 4.3). The second phase looked at how an intervention in the form of a workshop using hands-on practical activities influenced science teachers' conceptual development and disposition towards the use of practical activities in science (see Section 3.2.4).

In the context of my study it was obligatory for me to observe two of the participants from Phases 1 and 2 for closer study when using hands-on practical activities in their lessons based on the workshop which was carried out in Phase 2 (see Tables 6 and 7).

The data gathered in Phase 3 is aimed at answering my research sub-question 4:

> What factors enable or constrain science teachers when mediating learning using easily accessible resources to carry out practical activities in their science classrooms?

The chapter begins with a profile of the two teacher participants. This is followed by highlights of the lesson observations and semi-structured interviews. The chapter ends with some concluding remarks.

6.2 Teachers' profiles

Two Physical Science teachers from two different schools in two different regions of Namibia were involved in this study.

Teacher 1, Mrs Confidence (pseudonym) is a Physical Science teacher at Hope Secondary (pseudonym), a rural non-boarding school in northern Namibia that offers grades 8 to 11. She has a Basic Education Teacher Diploma (BETD) and an Advanced Certificate in Education (ACE) specialising in Mathematics with 10 years teaching experience in Physical Science at grades 8 to 10. She is currently doing her final year in the BEd honours program.

Teacher 2, Madam Physics (pseudonym) is a teacher at Millennium Secondary School (pseudonym), an urban non-boarding school in central Namibia offering grade 8 to 12. She has been teaching Physical Science from grade 8-12 and has 10 years teaching experience. Her teaching qualification is a Basic Education Teacher Diploma (BETD) and an advanced Diploma in Education specialising in Physical Science. She is currently doing her final year in the BEd honours program.

The pseudonyms used for these teachers are nicknames which they were given by their learners.

6.3 Qualitative results

The data from semi-structured interviews with Madam Physics (ITMP) and Mrs Confidence (ITC), as well as the data from their respective lesson observations (TMPO, TCO) were analysed. The data was colour coded in order to develop sub-themes which are related to my research sub-question 4 as well as to the literature. Table 16 shows the sub-themes which are aimed at answering research sub-question 1 which is:

> What factors enable or constrain science teachers when mediating learning using easily accessible resources to carry out practical activities in their science classrooms?

TABLE 16: PRELIMINARY THEMES FROM CODES

Code	Description of marked text	Sub-themes
ITMP	Learners were very much interested in that thing	Captures interest
TCO	Learners hold containers of different liquids which they brought from home and the teacher added universal indicator solution to each one of these liquids.	Active participation

TMPO	In the shops,.. at the supermarket …. at home …. in the kitchen	Links to real life/context
ITC	Now that we are having this UPE I think we can go back to buy those things for the materials	Cost of resources
ITC	The first one is the objects or the materials that were brought by the learners. Which means that in our environment there are materials which can be used in the classroom	Availability of resources
ITMP	Everybody wants to comment, everybody wants to	Stimulates questions and thinking
ITC	Maybe the time, the time also. Because in order to do these things you need to prepare them	Time constrains
ITC	The area where you have to carry out the experiments	Availability of classrooms/ store rooms

Table 17: Shows themes and supporting theory/literature which is aimed at answering research sub-question 4 which is:

> What factors enable or constrain science teachers when mediating learning using easily accessible resources to carry out practical activities in their science classrooms?

TABLE 17: THEMES AND SUPPORTING LITERATURE

Themes	**Theory/Literature**
Theme 1: Factors which enable teachers when mediating learning	
Active participation; Captures interest Links to real life/context Cost of resources; Availability of resources; stimulates questions and thinking	Maselwa and Ngcoza (2003);Kuhlane (2011); Kambeyo (2012); Uushona (2012); Shifafure (2014)

Theme 2 Factors which constrain teachers when mediating learning	
Time constraints Availability of classrooms/storerooms	Heeralal (2014)

I now discuss these two themes below.

6.4 Enabling and constraining factors during teaching

The main purpose of Phase 3 was to observe the teachers in the classroom, using easily accessible resources when carrying out practical activities. This was intended to establish the factors which enable or constrain them during their teaching. In the subsequent section, the enabling and constraining factors are expounded on.

6.4.1 Enabling factors during teaching

From the data, it appeared that the enthusiasm which learners showed during the lesson enabled the teachers to present their lessons using easily accessible resources with ease. For instance, in the semi-structured interviews, Madam Physics had this to say:

> "*Oh, my dear! I could say maybe learners are excited, I don't know as if I don't do practical activities before, learners were very much interested…. You know I teach in a multicultural school, I have different cultures and I even brought in Oshikundu, you know Oshikundu is just coming from a certain culture it is not for everybody, not all of them knows it...*"

She went on to say that:

> "*The fact that it produces a gas. The fact that it is supposed to be a home something, something to be cooked at home and the teacher just brought it to the class. How learners were enjoying that thing, it was a very interesting lesson, it was, myself I was as if I teach new learners, not the same learners that I usually teach because learners are asking questions, learners want to do things, even if they don't know how to do them like Oshikundu, it was a good experience*
>
> *…it is as if it is not the learners that I normally teach... They were very excited…. everybody wants to comment, everybody wants to ask*" (ITMP)**.**

Similarly, in the semi-structured interviews with Teacher Confidence, the following excerpts is what she narrated.

"Iyaa, it does because by looking at how we have carried out the experiments, you can really see that the learners are enjoying what they are doing. Because when I went to one class now they were asking me now because of those eggs that we have done with them yesterday, they are asking Ms, where are the eggs, we want to go back there. Then I said aaye you have to go there later, which means they are interested to see what is happening" (ITC).

Teacher Confidence continued to say that:

Ja, I really enjoyed doing those experiments because for me, I think not only the learners that have learned but even myself because I have never done those activities, neither with our school or when I become the teacher like having the universal indicator for the learners to do the colours. It was also an experience for me to see those things, the colours" (ITC).

The observations of Mrs Confidence indicated that her learners were eager to bring most of the resources to be used in the classroom. This enabled and motivated her to carry out the practical activities with them. She also seemed to have developed a positive attitude towards practical activities as she had initially indicated in Phase 2 that in the past she did not believe in conducting practical activities. She demonstrated a high degree of passion and enthusiasm towards practical activities using easily accessible resources in particular. Another aspect that emerged, which also enabled effective teaching in these lessons is the fact that learners were actively participating during the lessons as observed by the researcher during the classroom observation period. For instance, the learners in Figure 10 are blowing exhaled air through clear limewater to test for the presence of carbon dioxide in exhaled air.

LLL: [Each of the three learners bubbled their exhaled air through the clear limewater]. One girl appeared to be showing off through body language and showing excitement that she was given the opportunity to bubble her own exhaled air through the carbon dioxide.

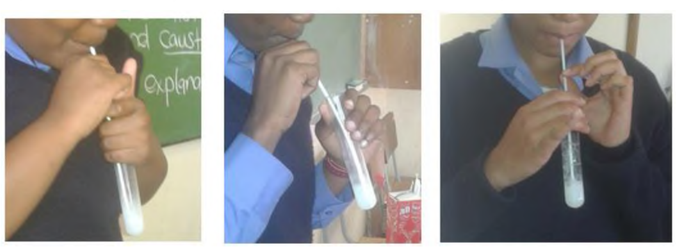

FIGURE 10: LEARNERS OF MILLENNIUM SECONDARY SCHOOL (PSEUDONYM) BLOWING EXHALED AIR THROUGH CLEAR LIMEWATER

Another sub-category of data which emerged is that when the teachers conducted the practical activities, they enabled effective links to the everyday lives and contexts of the learners. For instance, during the lesson observations, Madam Physics asked learners the following:

TMPO: "*Where have you see this one*"? [Holding baking soda and vinegar and asking learners to identify the substances].

LLL: *In the shops… at the supermarket… at home …. in the kitchen…* (learners' responses).

It was evident that the materials which the teacher used are those which learners are familiar with as they could mention where they are found.

In the reflections of the learners of Hope Secondary School, one of the learners narrated the following.

"*I feel so excited about these practicals that we had done because it's very important for us to observe and learn more about this experiments so that we understand that Physical Science is the learn[learning] of our local materials surrounding our environment. I had really enjoy it as it's also inspiring us to learn science*" (HL9 Learner 9).

In similar vein, another learner from Millennium Secondary School reflected.

"*It was a very great and exciting. It brought one thing to my mind that you can do science experiments with almost everything and it indicated that the world is mostly about science. It really brought my interest for science back*" (ML24 Learner 24).

During the practical activity on the effect of 98% concentrated sulfuric acid on white sugar, the following excerpts show links made to everyday life and local context.

TMPO: *Explaining that the class is going to do a practical activity outside, using concentrated sulfuric acid and white sugar. She explained that there is a need to do the practical activity outside and that they needed to observe what was happening.*

LLL: *sulfuric acid is battery acid… It will go "boom*"

LLL*: shouting and screaming, it looks like a bomb, this is a nuclear bomb, as they observe the effect of sulfuric acid on white sugar.*

FIGURE 11: EFFECT OF 98% CONCENTRATED SULFURIC ACID ON WHITE SUGAR

TMPO: *what happened to the white sugar*?

L: *it is like a volcano that erupted and solidified…*

L: *Miss the smell that came out was almost like for a tamalaitjie* [a tamalaitjie is an Afrikaans word for a fudge like sweet which is home made by heating white sugar until it turns brownish, which can be done when white sugar is mixed with fresh milk, condensed milk, and so on. It gives off a similar smell as the smell which learners experienced in this practical activity]

Another enabling factor which emerged is the availability and cost of the materials used to carry out hands-on practical activities. In the semi-structured interviews, Teacher Confidence had this to say about the availability of the materials.

> "*Iyaa, okay what I have enjoyed the most… The first one is the objects or the materials that were brought by the learners. Which means that in our environment there are materials which can be used in the classroom which means we don't have only to focus more on things that can be found or can be bought in the lab. So using those materials, it was so enjoyable and you can see the effects and the learners can able to make the observations themselves so it was enjoyable*" (ITC).

FIGURE 12: DIFFERENT LIQUIDS WHICH WERE BROUGHT BY THE LEARNERS FROM THEIR HOMES

FIGURE 13: EGGS PLACED IN DIFFERENT LIQUIDS

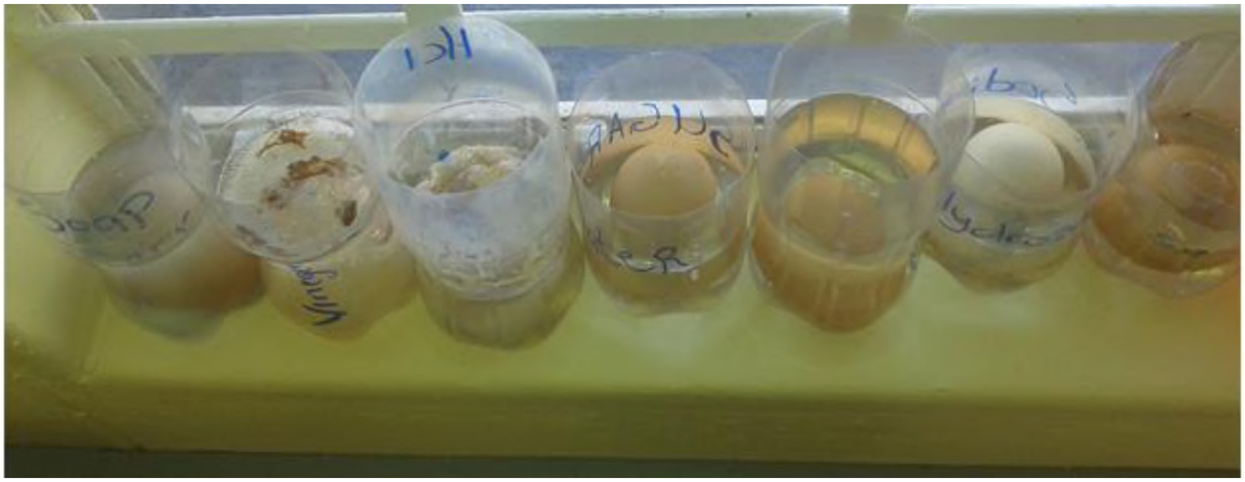

FIGURE 14: EFFECT OF DIFFERENT LIQUIDS ON THE EGGS AFTER 1 DAY

FIGURE 15: THE TRADITIONAL BEVERAGE ONTAKU/OSHIKUNDU

TCO: Takes various liquids that were brought by the learners and then informs the learners that she also has some liquids from the laboratory. She takes hydrochloric acid and shows it to the learners. She indicated to the learners that the hydrochloric acid is the diluted one not the concentrated one. She further showed vinegar, soapy water, caustic soda (sodium hydroxide). She explained that the caustic soda is added to water to dissolve it in order to form a solution (showing the caustic soda to all the learners while holding it in her hands). She also showed the 100% lemon juice, bleach (JIK), she asked if learners know JIK which is used for white shirts to become whiter. She also showed learners Domestos and explained that it is also used for cleaning.

TCO: She showed the learners universal indicator and the learners had never seen the universal indicator before.

Teacher Confidence also commented about the cost of the materials that these materials are not too expensive and the school will be able to buy some materials since learners will not be able to bring all the required materials from their homes.

> "*Now that we are having this UPE, because comparing with what we normally get from the SDF, we could not accommodate to buy those things. But looking at the amount that we have received, I think we can go back to buy those things for the materials*" (ITC).

The findings displayed above resonate well with the findings of the case studies of Kambeyo (2012), Kuhlane (2011), and Shifafure (2014) in which it emerged that the easily accessible resources used in their studies enabled learners to enjoy making links to the materials in their contexts. This in turn promoted learner engagement during the lessons as it was observed in my case study as well. Lupele and Lotz-Sisitka (2012) also confirm that when easily accessible resources are used to mediate learning, this deepens notions of inclusivity and makes connections between what is being said and what is meaningful to the learners.

6.4.2 Constraining factors during teaching

One of the constraining factor which emerged is the issue of time. When I observed these teachers, both of them conducted the practical activities in the afternoons. They could not conduct the practical activities during the normal lessons because of time constraints. The following excerpts show how the two teachers narrated the issue of time constraints.

> "*They think is okay I am a bit behind with my syllabus and I just thought of maybe let me just have my normal classes during the day and I can have it in the afternoon. Another reason is I thought it will take me a bit longer than the normal lesson duration, which is true, it took me so much longer and I did not want to do it myself quickly and I finish because of the time. I wanted to get learners involved also because if it is during the normal classes, I might cut them in doing, because you know when learners are involved in doing, they are sometimes a bit slow and I have to be patient and soon the bell just ring and they are not done*" (ITMP).

> "*And the other thing, maybe the time, the time also. Because in order to do these things you need to prepare them, and looking at our subjects that we are teaching, the subject allocation, sometimes that day is full, you won't even have time to go and do the preparation. Iyaa, so, now sometimes you have to… Like now sometimes I have to go up to five O'clock in order to do something for tomorrow*" (ITC).

In addition to time constraints, the issue of a venue or a suitable place to keep the materials also emerged as a constraining factor at Hope Secondary School in particular. From my observations, there is no store room or special classroom to keep the science materials or equipment unlike at Millennium Secondary School where there are laboratories and enough classrooms. During the time of the research, the materials were kept in a new classroom which was constructed this year (2016) and next year (2017) the classroom will be occupied by grade 12 learners because the curriculum of the school has been extended. This is a serious challenge because the classrooms which are used for normal teaching are always occupied by learners and there is a need for a special venue where the materials should be kept. Teacher Confidence had this to say about the venue.

> *"Iyaa the first one is the room. Because for now, we are just using this classroom but come next year, this classroom will be occupied by the grade 12s. Which means that we will not have any place where we can carry out our activities. As you know that these activities, they need a place for preparation, you need to prepare them somewhere. But now if we don't have that room so that we can come and prepare. That means... and to keep also, to keep them, it is a challenge. Because those learners, they have to check even the next day, that is why even when I did this part of, the beginning of this topic, when we were using the litmus paper, after I am done, we have to throw away those liquids because we have nowhere to keep them. Iyaaa"* (ITC).

Another concern raised regarding the venue was when Teacher Confidence explained that the school uses a system where teachers are the ones who rotate from one class to the other while learners are stationed in a fixed classroom. She explained that this system is difficult because if a teacher is responsible for different class groups, it means that as she is moving from one class to the other, she has to carry the required materials from one venue to the other.

> *"Okay, firstly, carrying the materials to the classroom is a challenge. Because you might take them there, or you need, you have more activities, I mean you have more materials. If you take them there, learners are learners, you will find that they have played with it. So when you take them there, by the time you come back and take their... for example you have those 3 buckets, you cannot carry them at the same time, you have to take some, or..."*

She continued to express concern that:

> *"And again, if you look at our classes, they are also full, even the area where you have to carry out the experiments, like this one that we have done now, you can see that, that table there, it makes it easy for all learners to come and move around and check what is happening. Now looking at the classrooms, even just the place where you have to carry out those ones, that is why when you check those classrooms they don't even have the table for*

the teacher, where the teacher have to put his or her books. You have to use learner's tables" (ITC).

The constraining factors which emerged from these data are supported by the findings of Heeralal (2014) based on his case study conducted in Gauteng, South Africa on the barriers experienced by natural science teachers in doing practical activities. It emerged that among others, time and lack of laboratories are some of the documented factors hindering teachers from successfully conducting practical activities.

6.5 Concluding remarks

In this chapter, I presented, analyzed and discussed the data that I gathered using observations, semi-structured interviews and reflections. The data from the observations showed that teachers are able to implement practical activities using easily accessible resources in their classrooms. However, from my observation, there are constraining factors that can hinder the proper implementation such as suitable venues in which to conduct the practical activities, time constraints and classroom size as well as the workload of the teachers. The data from observations were triangulated through the semi-structured interviews which were conducted after the teaching of practical activities. Although the focus was not on learners *per se*, their reflections revealed that they enjoyed the practical activities that were conducted using easily accessible resources form their homes and shops. It emerged that learners were keen to help the teachers by bringing some of the resources to the classrooms.

In the next chapter, I present a summary of my findings, recommendations and conclusions.

CHAPTER 7: SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSIONS

7.1 Introduction

Research has shown that a positive disposition in teachers can be cultivated through educational experience and professional development platforms (Hanisi, 2006; Jung & Rhodes, 2008; Ogunniyi & Hewson, 2008). Research has also demonstrated that the incorporation of culturally sensitive teaching methods in the teaching and learning repertoire helps to reduce the foreignness felt by learners, and enables a smooth border crossing between their everyday experience and the science classroom (Aikenhead & Jegede, 1999; Aikenhead, 2001; Kibirige & van Rooyen, 2006). The purpose of this study was to examine the effects of an intervention using easily accessible resources to carry out hands-on practical activities in science.

For my theoretical frameworks, I employed sociocultural theory (Vygotsky, 1978) and Pedagogical Content Knowledge (Shulman, 1986, 1987). I also used as conceptual lenses the notions of conceptual development, theoretical development and disposition. A mixed methods approach was employed to ascertain how an intervention in the form of a workshop influenced participants' conceptual development and disposition towards the use of practical activities in science.

In this chapter, I summarise the findings of my study and provide some recommendations for future research. I also acknowledge the limitations of my study and conclude with some general reflection on the project.

7.2 Summary of findings

The data were gathered and analysed in order to answer my four research sub-questions. The summary of the study is therefore presented in relation to my research sub-questions,

Research sub-question 1:

What are science teachers' experiences of doing hands-on practical activities in their science classrooms?

The data which responded to research sub-question 1, are presented in Chapter 4 (see Section 4.4.2). It was revealed that some teachers did not have experience in conducting practical activities in their classroom, even though they taught Physical Science, Natural Science, Life Science and Biology. Five examples of basic practical activities on carbon dioxide were asked about, and although the concept of carbon dioxide straddles all the natural science subjects, some teachers indicated that they had had no experience of conducting up to four practical activities. It also emerged that in cases where there was mention of practical activities, these had happened mainly with the use of conventional laboratory chemicals and equipment.

Research sub-question 2:

What factors influence science teachers' experiences of doing hands-on practical activities in their science classrooms?

The data responding to this research sub-question are also presented in Chapter 4 (see Section 4.4.1). It emerged that the examples of apparatus and chemicals that were given by the participants were mainly conventional materials and equipment. This resonated with the data speaking to research sub-question 1, because it shows that the way in which the teachers had experienced science during their studies (school, tertiary institutions, and professional development workshops) is in most cases the way they present it to their learners. Also, in many instances, teachers seemed unable to remember having conducted practical activities, while some indicated that the subject was taught only theoretically. There was little mention of the use of easily accessible resources.

The participants also went on to indicate the factors which enabled or constrained them from conducting practical activities in their teaching. It emerged that availability and prior knowledge of relevant materials would enable them to carry out practical activities. It also emerged that the lack of chemicals, equipment and laboratories in schools as well as time is a barrier to conducting practical activities.

Research sub-question 3:

How did the intervention in the form of a workshop influence science teachers' conceptual development and dispositions towards practical activities in science?

The quantitative results presented in Section 5.2 revealed that most of the participants had not had exposure to the use of easily accessible resources to carry out practical activities, as shown in Figure 5. This figure further revealed that those who have had experience of doing practical activities have mainly used conventional materials. It emerged that there a degree of change occurred in the attitude of participants towards doing practical activities in the science classroom, as shown in Figure 6.

These quantitative results were corroborated by the qualitative results presented in Section 5.3. The main themes which emerged, as shown in Table 14, are learning with understanding, knowledge of resources, interest and participation, and continuous professional development. There was consistent data from participants that showed that using easily accessible resources to carry out hands-on practical activities enabled them to learn with understanding. This may be because easily accessible resources enable them to make links between science and real life and use their own observations as evidence. This in turn may enable them to come up with scientific concepts. These insights are in line with Vygotsky's (1978) sociocultural theory, which states that meaning making is enhanced when people engage with materials which are made available to them in their real-world contexts. This is also in line with Aikenhead and Jegede (1999) and Aikenhead (2001), who indicate that culturally sensitive teaching methods reduce the foreignness experienced during the learning of scientific concepts and enhances the smoothness of crossing the border between everyday life and classroom experience.

Participants in this study also highlighted the issue of knowledge of resources. They indicated that although they were familiar with most of the resources used during the practical activities conducted in the workshop (as summarised in Table 5), they had not thought to use these during their lessons. They agreed that we were surrounded by a lot of potentially useful materials, and that we just needed to learn how to use these materials and to improvise with them. They indicated that often they were just not aware that certain materials in their environments and local supermarkets could be used to conduct practical activities in science. They also realised that some materials do not need to be bought, but are simply obtainable in the environment, and that those that need to be bought are relatively inexpensive. This is in line with Shulman (1986, 1987), who indicates that in order for teachers to be able to incorporate locally available materials in their lessons, they should have basic knowledge of these materials.

Further results of this case study show that using easily accessible resources promotes interest and participation. It emerged persistently that participants were interested in the activities because the materials were not foreign but familiar. It also emerged that this enabled them to ask questions and think critically. In this way they were able actively participate in the lesson. This is in line with the findings of Ngcoza, et al. (2016) that the participation of learners in the science expo serves to stimulate them to study science in school.

The data from this case study has also provided some insights into continuous professional development. In their reflections, all 21 participants unanimously recommended that these kinds of workshops should be conducted with other teachers in Namibia (see Appendix E). Two of the participants who are involved in the professional development of teachers indicated that they would plan similar workshops with their colleagues at circuit level. Some of the participant teachers also indicated that they would share these ideas with their colleagues at school. All in all, participants were in favour of the use of easily accessible resources to carry out practical activities in the science classroom. These recommendations are in line with a large body of literature which recommends professional development as a way of cultivating positive attitudes in teachers towards the incorporation of indigenous knowledge in science (e.g. Kibirige and van Rooyen, 2006; Ogunniyi & Ogawa, 2008; Shizha, 2007).

Research sub-question 4:

What factors enable or constrain science teachers when mediating learning using easily accessible resources to carry out practical activities in their science classrooms?

The data responding to this question is presented in Chapter 6, Section 6.3. The main themes which emerged are shown in Table 17, divided into enabling factors and constraining factors. What emerged strongly from this data was that the major enabling factors are the enthusiasm and participation on the part of learners when their teachers mediated learning using easily accessible resources to carry out practical activities. Two teachers indicated that they enjoyed it when the classroom became alive as learners were excited by the use of easily accessible resources. It also emerged that learners evinced a high degree of participation by asking questions.

On the other hand, the data also showed that there are some factors which could possibly hinder teachers from implementing such activities successfully. These include the unavailability of classrooms or store rooms in which to keep the materials for practical activities. This was especially the case with Mrs Confidence, because there is a shortage of classrooms at the school where she works and there are no extra rooms to keep resources. Another challenge that was mentioned is that of time, because the practical activities were in both cases conducted during the afternoon. The reason given was that the normal 40 minute lesson is too short to carry out practical activities thoroughly, obliging the teacher to rush through the activities and not implement them successfully.

7.3 Recommendations

This case study has generated further research possibilities. Most importantly, it would be interesting to carry out more research based on classroom observation of teachers using easily accessible resources to carry out practical activities during their science lessons. As the literature argues, in order for teachers to use materials, they should have the necessary knowledge of and exposure to the use of the materials. It is therefore imperative to conduct extensive research via the observation of actual teaching by the teachers after they have been exposed to such materials. Further recommendations are based on the curriculum, learning and teaching support materials (LTSMs), subject content knowledge and teamwork.

- **Curriculum**

  Based on the findings of this study, it emerged that the curriculum is not explicit on how teachers should go about incorporating local materials in their science classrooms. For instance, in the syllabuses for the natural sciences subjects, the practical activities and demonstrations that are included are based only on conventional science material and equipment. There is little mention of local materials. This could be improved by suggesting a greater use of easily accessible resources as well as conventional materials.

- **Learning and teaching support materials (LTSMs)**

  Textbook authors and persons involved in developing learning and teaching support materials could also consider including more practical activities which draw on examples from the Namibian context. This would enable the teachers to try out practical activities using easily accessible resources which they might not otherwise have been aware of.

- **Subject content knowledge**

  Teachers are also encouraged to try and keep abreast of their subject content knowledge, since, as Shulman (1978) insists, subject matter knowledge precedes pedagogical content knowledge. This means that in order for teachers to be able to recognise easily accessible resources in their environments and possibly use these in their teaching and learning, they should have a sound knowledge of their subject content knowledge.

- **Team work**

  It is also recommended that team work is strengthened among teachers so that they are able to share their good practices with one another. This is in line with Lave and Wenger's (1991) contention that learning takes place in active communities of practice. For instance, when teachers attend professional development platforms, they should go back and share with their colleagues. Also, the officials who are responsible for subject coordination should establish opportunities for teachers to come together and share best practices.

7.4 Limitations of the study

One of the limitations of this study is the size of the sample. A total of 21 participants participated in Phases 1 and 2 and two participants participated in Phase 3. The smallness of the sample means that the findings of the study are not necessarily generalizable to all teachers in Namibia. Similar research could be carried out that focuses on a larger sample of participants. However, since the sample was comprised of different teachers from different regions in Namibia, the findings could nevertheless provide insights into teaching and learning practices across Namibia.

Another limitation could be that these participants were all doing their BEd Honours program and I was doing my master's program. It could be that my seniority in terms of studies could have influenced them to participate and it might be that if I was just their fellow BEd Honours classmate, they might not have participated to the extent that they did. It was of course explained from the outset that participation was voluntary and that the participants had the right to withdraw at any time.

7.5 Conclusion

This study illuminated the importance of the intervention as an educational experience aimed at cultivating a positive disposition in teachers towards use of practical activities in their science classrooms. Preliminary evidence showed that, according to the way learners responded to examination questions relating to practical skills, it appears that they were not being sufficiently prepared. The study revealed that the dominant factor hindering their carrying out of practical activities is their perception of the lack of chemicals, equipment and laboratories. It further revealed that there were materials available in local contexts – from the natural environment or from supermarkets – that can be used to carry our practical activities. For this to happen, teachers need to be made aware of these resources (Shulman, 1986, 1987).

The study further highlighted that if teachers engage in hands-on practical activities using easily accessible resources at pre-service or in-service level, they will be able to implement these activities even if they find themselves teaching in under-resourced schools. It was thus found to be imperative that the use of easily accessible resources to carry out hands-on practical activities be encouraged at teacher professional development level, so that teachers are prepared to teach in different kinds of school in different contexts.

The thesis ends by concluding that various stakeholders responsible for teacher professional development should work collaboratively with teachers in order to create platforms where teachers can engage in conducting hands-on practical activities using easily accessible resources. Science education is seen as the main vehicle through which the development and quality of life of any country can be realised (Brock-Utne, 2001). This requires the careful preparation of teachers to enable them to prepare learners to specialise in Science, Technology, Mathematics and Engineering (STEM) courses (Ostler, 2012; Curriculum Development Council, 2015). In Namibia, this is particularly important for the realisation of the envisaged Vision 2030, “a prosperous and industrialised Namibia developed by her human resources” (Namibia. MoE, NCBE, 2010, p.2).

7.6 Epilogue

My research journey was such a rewarding and learning experience. Firstly, my research could not have been better scheduled because at the time of doing this research, I had just started in a new working environment as a curriculum education officer for Physical Science. At the same time, Namibia is in the process of implementing the revised curriculum, and all the curriculum officials were expected to conduct national workshops on the revised syllabuses. In my case, I facilitated national workshops for Physical Science and also assisted with Agricultural Science because the post for education officer for Agricultural Science is vacant.

As a result of the recommendations I received from my research participants that it is necessary to carry out the activities which were carried out during the intervention with other teachers in Namibia, I became tempted to use some of the activities as 'ice-breakers' during these workshops. I had such a wonderful experience because I conducted five workshops nationally. Based on the evaluation that I received from the participants (because workshop participants complete evaluation forms at the end of the workshop), I became more motivated to conduct similar workshops during other professional development platforms in Namibia. I have also learned about more interesting practical activities from some workshop participants in the process. When I conducted the national workshops, the facilitators who attended were required to go and conduct similar workshops at regional levels. Interestingly, I received some feedback from some of them that they had also included some of these hands-on practical activities in their workshops as 'ice breakers', and that it was a wonderful experience.

In November 2016, I participated in a similar workshop organised by UNESCO in collaboration with the University of Namibia (UNAM). This workshop was on Active Learning in Optics and Photonics (ALOP), which targets developing countries. It was conducted in a similar manner to my intervention by facilitators from Australia and Tunisia, respectively. During the workshop, we made use of easily accessible resources to conduct practical activities on the concepts of optics and photonics. Participating in this workshop motivated me further because I came to realise that the notion of using easily accessible resources to carry out hands-on practical activities is gaining momentum in different parts of the world. From this workshop, we are required to conduct similar ALOP workshops in Namibia and I feel that my research has prepared me in this regard.

This research journey has contributed to my personal and professional development. My computer skills have improved, I am more passionate about continuous professional development and I am also more passionate about conducting hands-on practical activities using easily accessible resources than before. I did not consciously consider incorporating indigenous ways of knowing in my lessons before, but this research journey made me develop a special passion for indigenous knowledge systems and integrating them into teaching. I have also learned that language is an essential tool in teaching and learning. Before the MEd journey, I considered myself as just a science teacher. Although I knew that I taught science through language as a tool and medium of instruction, I am now more conscious about the role of language in science than before.

In spite of the fact that my research journey was a wonderful learning experience, it was also a frustrating journey and I can hardly believe that I have managed to reach the end of it. As I indicated earlier, starting in a new working environment meant that I had a lot of pressure from work. I was in the process of learning and adapting to the new working environment while at the same time attending to my studies. On two different occasions, I missed contact sessions because I had to attend to my work. For the revision of the syllabuses, I had a lot of deadlines to meet as per the requirements of Cambridge International Examinations (CIE), our accreditation body. I had a tough time balancing work and study, both important for my professional development.

References

Abrahams, I., & Millar, R. (2008). Does practical work really work? A study of the effectiveness of practical work as a teaching and learning method in school science. *International Journal of Science Education, 30*(14), 1945-1969.

Aikenhead, G. S., & Jegede, O. J. (1999). Cross-cultural science education: A cognitive explanation for a cultural phenomenon. *Journal of Research in Science Teaching, 36*(3), 269-287.

Aikenhead, G. S. (2001). Students' ease in crossing cultural borders into school science. *Science Education*, *85*(2), 180-188 Asafo-Adjei, R. T. (2004). *From imifino to umfuno: A case study foregrounding indigenous agricultural knowledge in school-based curriculum development*. Unpublished master's thesis, Education Department, Rhodes University, Grahamstown.

Asheela, E. N., Ngcoza, M. N., & Enghono, A. (2015). An indigenous practice of making a traditional beverage called Oshikundu as a strategy to enhance conceptual undertanding. In M. B. Ogunniyi & K. R. Langenhoven (Eds.), *The relevance of indigenous knowledge to African socioeconomic development in the 21st Century. African Association for the Study of Indigenous Knowledge Systems* (pp. 282-289). UNAM, Windhoek.

Atallah, F., Bryant, S. L., & Dada, R. (2010). Learners' and teachers' conceptions and dispositions of mathematics from a Middle Eastern perspective**.** *US-China Education Review*, *7*(8), 43-49.

Bertram, C., & Christiansen, I. (2015). *Understanding research: An introduction to reading research*. Pretoria: Van Schaik Publishers.

Breidlid, A. (2009). Culture, indigenous knowledge systems and sustainable development: A critical view of education in an African context. *International Journal of Education Development, 29*(2), 140-148.

Brock-Utne, B. (2001). Education for all: In whose language? *Oxford Review of Education*, *27* (1), 115-134.

Cohen, L., Manion, L., & Morrison, K. (2011). *Research methods in education* (6th ed.). London: Routledge Falmer.

Corlu, M. S., Caprano, R. M., & Caprano, M. M. (2014). Introducing STEM education: Implications for educating our teachers for the age of innovation. *Education and Science*, (39), 171.

Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (4th ed.). Boston: Pearson Education.

Crick, R. D., & Yu, G. (2008). Assessing learning dispositions: Is the effective lifelong learning inventory valid and reliable as a measurement tool? *Educational Research, 50*(4), 387-402.

Cronje, A., De Beer, J. & Ankiewicz, P. (2015). The development and use of an instrument to investigate science teachers' views on indigenous knowledge. *African Journal of Research in Mathematics, Science and Technology Education*, *19*(3), 319-332.

Curriculum Development Council. (2015). *Promotion of STEM education: Unleashing potential in innovation*. Retrieved from: http://www.edb.gov.hk/attachment/en/curriculum development/renewal/Brief%20on%20STEM%20(Overview) _eng_20151105.pdf

Enghono, A. M. (2013). *Understanding how trainee science teachers engage with prior everyday knowledge and experiences associated with biological concepts during Biology lessons: A case study*. Unpublished master's thesis, Rhodes University, Grahamstown.

Erdogan, N., & Stuessy, C. L. (2015). Modeling successful STEM high schools in the United States: An ecology framework. *International Journal of Education in Mathematics, Science and Technology*, *3*(1), 77-92.

Erinosho, S. Y. (2013). Integrating indigenous science with school science for enhanced learning: A Nigerian example. *International Journal for Cross-Disciplinary Subjects in Education* (IJCDSE), *4*(2), 1137-1143.

Fah, L. Y., Areepattamannil, S., Thoe, N. K., & Hoon, K. C. (2015). *Dispositions towards science and science achievement in TIMSS 2011: A comparison of eighth graders in Hong Kong, Chinese Taipei, Japan, Korea, and Singapore*. New Perspectives in Science Education, Edition 4. International Conference, March 2015, Florence, Italy. Retrieved: January, 2016, http://conference.pixel-online.net/NPSE/files/npse/ed0004/FP/1512-ESM912-FP- NPSE4.pdf

Gott, R., & Duggan, S. (1996). Practical work: Its role in the understanding of evidence in science. *International Journal of Science Education, 18*(7), 791-806.

Grant, R. (2015). Notes on examples and activities from Grant's workshop: The use of everyday materials for practical activities in the science classroom [Lecture notes], Rhodes University, Grahamstown.

Harwell, S. H. (2003). *Teacher professional development: It's not an event, It's a process*. Texas. CORD.

Hanisi, N. (2006). *Nguni fermented foods: Working with indigenous knowledge in the Life Sciences: A case study*. Unpublished master's thesis, Education Department, Rhodes University, Grahamstown.

Heeralal, P. J. H. (2014). Barriers Experienced by Natural Science Teachers in Doing Practical Work in Primary Schools in Gauteng. *International Journal of Science Education*, *7*(3), 795-800.

Hewson, P. W. (1992). *Conceptual change in science teaching and teacher education*. Paper presented at a meeting on "Research and Curriculum Development in Science Teaching". Madrid, Spain.

Hodson, D. (1990). A critical look at practical work in school science. *School Science Review*, *70*(256), 33-40.

Hodson, D. (2009). *Teaching and learning about science: Language, theories, methods, history, traditions and values*. Rotterdam: Sense Publishers.

Horsthemke, K., & Schäfer, M. (2007). Does 'African mathematics' facilitate access to mathematics? Towards an ongoing critical analysis of ethnomathematics in a South African context. *Pythagoras, 65*, 2-9.

Howes, A., Kaneva, D., Swanson, D., & Williams, J. (2013). *Re-envisioning STEM education: Curriculum, assessment and integrated, interdisciplinary studies*. Vision for C & A Royal, The University of Manchester. Retrieved September, 2014, https://royalsociety.org/~/media/education/policy/vision/reports/ev-2-vision-research-report-20140624.pdf

Howie, S. (2004). A national assessment in mathematics within an international comparative assessment. *Perspectives in Education, 22*(2), 149-162.

Jabareen, Y. (2009). Building a conceptual framework: Philosophy, definitions and procedure. *International Journal of Qualitative Methods*. Retrieved July, 2016, from http://creativecommons.org/licenses/by/20

Jaworski, B. (1993). *Constructivism and teaching: The sociocultural context*. Retrieved October, 2011, from http://www.grout.demon.co.uk/Barbara/chreods.htm

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *American Educational Research Association*, *33*(7), 14-26.

Johnstone, A. H. (2010). You can't get there from here. *Journal of Chemical Education*, *87*(1), 22-29.

Jokiranta, K. (2014). *The effectiveness of practical work in science education*. Unpublished bachelor's thesis, University of Jyväskylä.

Jung, E., & Rhodes, D. M. (2008). Revisiting disposition assessment in teacher education: Broadening the focus. *Assessment & Evaluation in Higher Education, 33*(6), 647-660.

Kambeyo, L. (2012). *An investigation into how grade 9 Physical Science learners make meaning of the topic on acids and bases through exploring their prior everyday knowledge and experiences: A case study*. Unpublished master's thesis, Rhodes University, Grahamstown.

Kasanda, C., Lubben, F., Gaoseb, N., Kandjeo-Marenga, U., Kapenda, H., & Campbell, B. (2005). The role of everyday contexts in learner centred teaching: The practice in Namibian secondary schools. *International Journal of Science Education*, *27*(15), 1805-1823.

Katz, L. G. (1993). *Dispositions as educational goals*. Retrieved from Eric digests.www.eric.ed.gov

Kibirige, I., & Van Rooyen, H. (2006). Enriching science teaching through the inclusion of indigenous knowledge. In J. De Beers & H. van Rooyen (Eds.), *Teaching science in the OBE classroom*. Braamfontein: Macmillan.

Klein, J. (2011). Indigenous knowledge and education–the case of the Nama people in Namibia. *Education as change*, *15*(1), 81-94

Kuhlane, Z. (2011). *An investigation into the benefits of integrating learners' prior everyday knowledge and experiences during teaching and learning of acids and bases in grade 7: A case study*. Unpublished master's thesis. Education Department, Rhodes University, Grahamstown.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.

Leach, J., & Scott, P. (2003). Individual and sociocultural views of learning in science education. *Science & Education*, *12*(1), 91-113.

Le Grange, L. (2007). Integrating western and indigenous knowledge systems: The basis for effective science education in South Africa? *International Review of Education*, *53*(5-6), 577-591.

Lemke, J. L. (2001). Articulating communities: Social perspectives on science education. *Journal of Research in Science Teaching, 38*(3), 296-316.

Lotz-Sisitka, H., Olvitt, L., Gumede, M., & Pesanayi, T. (2006). *ESD practice in southern Africa: Supporting participation in the UN Decade of Education for Sustainable Development*. Howick: SADC REEP.

Lotz-Sisitka, H., & Russo, V. (2003). *Development, adaptation and use of learning support materials: In support of environmental education processes.* SADC Regional Environmental Education Programme Course Developers' Toolkit. Howick, Share-Net.

Lupele, J., & Lotz-Sisitka, H. B. (2012). *Learning today for tomorrow: Sustainable development learning processes in sub-Saharan Africa*. Howick: SADC. REEP.

Maree, K. (Ed.). (2011). *First steps in research.* Pretoria: Van Schaik Publishers.

Maselwa, M. R., & Ngcoza, K. M. (2003). 'Hands-On', 'minds-on' and 'words-on' practical activities in electrostatics: Towards conceptual understanding. In D. Fisher & T. Marsh (Eds), *Making Science, Mathematics and Technology Education accessible to all. Proceedings of the Third International Conference on Science, Mathematics and Technology Education.* Perth: Key Centre for School Science and Mathematics.

Mbangula, C. N. (2010). *An investigation of grade 11 Oshindonga teachers' understanding and implementation of the learner-centered approach adopted in Namibia: A case study.* Unpublished master's thesis. Education Department, Rhodes University, Grahamstown.

Merriam, S. B. (2009). *Qualitative research: A guide to design and implementation* (2nd ed.). San Francisco: Jossey-Bass.

Millar, R. (2010). *Developing students' understanding of science: The role of practical work.* Metodelab conference, lecture notes, University of York, Department of Education, Copenhagen.

Mizell, H. (2010). *Why professional development matters*? United States. Retrieved August, 2014, from https://learningforward.org/doc/pdf/why_pd_matters_web.pdf

Mukwambo, M. (2012). *Understanding trainee teachers' engagement with prior everyday knowledge and experiences in teaching Physical Science concepts: A case study.* Unpublished master's thesis. Education Department, Rhodes University, Grahamstown.

Mukwambo, M., Ngcoza, K., & Chikunda, C. (2014). Africanisation, Ubuntu and IKS: A learner-centered approach. In C.I.O. Okeke, M. M. van Wyk & N. T. Phasha (Eds.), *Schooling, society and inclusive education: An African perspective*. Cape Town: Oxford University Press.

Namibia. (1988). Constitution of the Republic of Namibia, Windhoek.

Namibia. Ministry of Education and Culture. (1993). *Toward education for all: A development brief for education, culture and training.* Okahandja. NIED.

Namibia. Ministry of Education. (2008). *Physical Science Subject Policy Guide: Grades 8 to 12.* Okahandja, NIED.

Namibia. Ministry of Education. (NCBE). (2010). *The National Curriculum for Basic Education*. Okahandja, NIED.

Namibia. Ministry of Education. (2010). *Namibia Junior Secondary Certificate (JSC) Physical Science*. Okahandja, NIED.

Namibia. Ministry of Education. (2010). *Namibia Senior Secondary Certificate (NSSC) Physical Science Syllabus Ordinary Level*. Okahandja, NIED.

Namibia. Ministry of Education. (2010). *Namibia Senior Secondary Certificate Physical Science syllabus Higher Level.* Okahandja, NIED.

Namibia. Ministry of Education. (2010). *Report on the Examinations NSSCH*. Windhoek. DNEA.

Namibia. Ministry of Education. (2011). *Report on the Examinations NSSCO/H*. Windhoek: DNEA.

Namibia. Ministry of Education. (2012). *Report on the Examinations NSSCO/H.* Windhoek: DNEA.

Namibia. Ministry of Education. (2013). *Report on the Examinations NSSCO/H.* Windhoek: DNEA.

Namibia. Ministry of Education. (2014). *Report on the Examinations NSSCO/H.* Windhoek: DNEA.

Namibia. Ministry of Education. (2012). *Report on the Examinations JSC*. Windhoek: DNEA.

Namibia. Ministry of Education. (2013). *Report on the Examinations JSC*. Windhoek: DNEA.

Namibia. Ministry of Education. (2014). *Report on the Examinations JSC*. Windhoek: DNEA.

National Research Council. (2011). *Successful K-12 STEM Education: Identifying effective approaches in Science, Technology, Engineering, and Mathematics.* Committee on Highly Successful Science Programs for K-12 Science Education. Board on Science Education and Board on Testing and Assessment, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

Neuman, L. W. (2011). *Social research methods: Qualitative and quantitative approaches* (7th ed.) Boston: Pearson.

Ngcoza, K. M. (2007). *Science teachers' transformative and continuous professional development: A journey towards capacity-building and reflexive practice.* Unpublished doctoral thesis, Education Department, Rhodes University, South Africa.

Ngcoza, K. M., Sewry, J., Chikunda, C., & Kahenge, W. (2016). Stakeholders' perceptions of participation in science expos: A South African case study. *African Journal of Research in Mathematics, Science and Technology Education, 20* (2), 189-199.

Ngcoza, K. M., & Southwood, S. (2016). Webs of development: Professional networks as spaces for learning. *International Journal of Educational Development* (In Progress).

Nicodemus, K. S., & Ngcoza, K. M. (2015). Making sense of concepts on rates of reaction through the inclusion of indigenous practice of making Oshikundu: A Namibian perspective. In M. B. Ogunniyi & K. R. Langenhoven (Eds.), *The relevance of indigenous knowledge to African socioeconomic development in the 21st Century. African Association for the Study of Indigenous Knowledge Systems* (pp. 7-16). UNAM, Windhoek.

Nyambe, J. K. (2008). *Teachers' interpretation of learner-centered education pedagogy: A case study.* Unpublished doctoral thesis, Education Department, Rhodes University, Grahamstown, South Africa.

Nyambe, J. K., & Wilmot, D. (2012). New pedagogy, old pedagogic structures: A fork-tongued discourse in Namibian teacher education reform. *Journal of Education, 55,* 55-82

O'Donoghue, R., Lotz-Sisitka, H., Asafo-Adjei, R., Kota, L., & Hanisi, N. (2007). Exploring learning interactions arising in school-in-community context of socio-ecological risk. In A. E. J. Walls (Ed.), *Social learning towards a sustainable world* (pp. 435-447). The Netherlands: Wageningen Academic.

Ogunniyi, M. B., & Ogawa, M. (2008).The prospects and challenges of training South African and Japanese educators to enact an indigenised science curriculum. *South Africa Journal of Higher Education, 22*(1), 175-190.

Ogunniyi, M. B., & Hewson, M. G. (2008). Effect of an argumentation-based course on teachers' disposition towards a science-indigenous knowledge curriculum. *International Journal of Environmental & Science Education, 3*(4), 159-177.

Oloruntegbe, K. O., & Ikpe, A. (2011). Ecocultural factors in students' ability to relate science concepts learned at school and experienced at home: Implications for chemistry education. *Journal of Chemical Education, 88*(3), 266-287.

Ostler, E. (2012). 21st Century STEM education: A tactical model for long-range success *International Journal of Applied Science and Technology, 2*(1), 28-33.

Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education*, *93*(3), 223-231.

Roschelle, J. (1995). *Learning interactive environments prior knowledge and new experience*. Retrieved March, 2014, from http://www.exploratorium.edu/ifi/resources/museueducation/priorknowledge.html

Shifafure, A. M. (2014). *Understanding how grade 11 Physical Science teachers mediate learning of the topic distillation in the Kavango Region*. Unpublished master's thesis. Education Department, Rhodes University, Grahamstown, South Africa.

Shizha, E. (2007). Critical analysis of problems encountered in incorporating indigenous knowledge in science teaching by primary school teachers in Zimbabwe. *The Alberta Journal of Education Research, 53*(3), 302-319.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational researcher*, *15*(2), 4-14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of new reform. *Harvard Educational Review, 57*(1), 1-21.

Sinclair, M. (2007). A guide to understanding theoretical and conceptual frameworks. *Evidence Based Midwifery, 5*(2), 39-55.

Stears, M., Malcolm, C., & Kowlas, L. (2003). Making use of everyday knowledge in the science classroom. *African Journal of Research in Mathematics, Science and Technology Education*, *7*(1), 109-118.

Taylor, N. (1999). *Curriculum 2005: Finding a balance between school and everyday knowledges*. In N. Taylor, & P. Vinjevold (Eds.), *Getting learning right: Report of the President's Education Initiative Research Project* (pp. 105-130). Braamfontein: Joint Education Trust.

Turuk, M. C. (2008). The relevance and implications of Vygotsky's sociocultural theory in the second language classroom. *Annual Review of Education Communication and Language Sciences*, *5*, 244-262.

Uushona, K. I. T. (2012). *An investigation into how grade 9 learners make sense of the fermentation and distillation processes through exploring the indigenous practice of making the traditional alcoholic beverage called Ombike: A case study*. Unpublished master's thesis. Education Department, Rhodes University, Grahamstown, South Africa.

Van Driel, J. H. (2010). International encyclopaedia of education (3rd ed.). *Statistics Teacher Education*, 7, 656-661.

Vhurumuku, E., & Mokeleche, M. (2009). The nature of science and indigenous knowledge systems in South Africa, 2000–2007: A critical review of the research in science education. *African Journal of Research in Mathematics, Science and Technology Education*, *13*(sup1), 96-114.

Vygotsky, L. S. (1978). *Mind in society: Interaction between learning and development.* Cambridge, MA: Harvard University Press.

Woodley, E. (2009). Practical work in school science: Why is it important? *School Science Review*, *91*(335), 49-51.

APPENDICES

Appendix A: Informed consent letter to research participants

RHODES UNIVERSITY
Grahamstown • 6140 • South Africa

EDUCATION DEPARTMENT

Tel: +27 (0) 46 603 8383

Fax: +27 (0) 46 622 8028

PO Box 94, Grahamstown, 6140

06 January 2016
Dear Research Participant
Re: Participation in research on the use of easily accessible resources in the topic on formation of carbon dioxide in Physical Science lessons

Thank you for agreeing to be a research participant in my study. As per our discussion, my research area is 'How exposure to the use of easily accessible resources in the topic on formation of carbon dioxide influences Physical Science teachers' dispositions towards science'.

The study will be conducted in **three** phases. The first phase requires participants to complete a questionnaire. The **second phase** of the study involves an intervention in the form of a workshop on training participants on the use of easily accessible resources in science classrooms. After the intervention, **the third phase** of the study requires volunteers for further research on implementation on the use of easily accessible resources in their classrooms.

Your participation in this research study is completely voluntary and you can withdraw at any time. The data collected in this study will be published as a Rhodes University half thesis. The identity of each participant and their views or contributions will be treated with a high degree of confidentiality and anonymity.

Sincerely

Eva Asheela
Rhodes University
MEd in Science Education Student

Dr K. Ngcoza (Supervisor)
Rhodes University

I agree to participate in the research on condition that I can withdraw at any time.
Name…………………………………………………………………………………
Signature……………………………………………………………………………..
Contact number……………………………………………………………………

Appendix B1: Questionnaire to participants

SURVEY ON THE USE OF EASILY ACCESSIBLE RESOURCES TO DO PRACTICAL ACTIVITIES IN A PHYSICAL SCIENCE CLASSROOM.

I, **Eva Ndagwedha Asheela,** student no **13a7193** am doing a **Master in Education (Science Education)** with Rhodes University. I would like to request the Bachelor of Education (honours) students (Physical Science) to kindly complete this questionnaire to help me to carry out my research. The information obtained in this questionnaire will be anonymous and your name will not be used. Please do not write your name and answer all the questions as free as you wish.

Part A

Professional Profiling of Teachers

Please tick (√) the appropriate box:

1. Gender

Male	Female

2. Qualifications (qualifications you have)

ECP	BETD	ACE/FDE	BEd-Hons	MEd	PHD	Non-Education Qualifications

3. Teaching qualification in Physical Science

4. Teaching experience in Physical Science and total number of years.

Grade (s)	8	9	10	11	12
Number of years teaching experience					

4. Age group (please tick)

20-25 years	26-30 years	31 – 35 years	36 – 40 years	41 – 45 years	46 – 50 years	Above 50 years

5. I am a (please tick**)**

Teacher	Head of Department	Principal	Education officer	Lecturer	Other (please specify)

Part B

6. Your pre-service (school/college/university) experiences on how you were taught the topic on formation of carbon dioxide gas.

(a) How were you taught the preparation of carbon dioxide gas in the classroom/laboratory? Give details of any practical activities/demonstration used as well as the resources, i.e. chemicals/substances.
(b) (b) How were you taught that carbon dioxide gas is acidic? Give details of any practical activities/demonstration carried out as well as the resources, i.e. chemicals/substances.
(c) How were you taught that carbon dioxide gas does not support combustion? Give details of any practical activities/demonstration carried out as well as the resources, i.e. chemicals/substances.
(d) How were you taught on testing that carbon dioxide is a greenhouse gas and contributes to global warming? Give details of any practical activities/demonstration carried out as well as the resources, i.e. chemicals/substances.
(e) How were you taught about carbon dioxide gas in nature in terms of the processes of respiration and photosynthesis? Give details of any practical activities/demonstration carried out as well as the resources, i.e. chemicals/substances

7. Your experiences on teaching the topic on formation of carbon dioxide.

(a) How do you prepare carbon dioxide gas in the classroom/laboratory with your learners? Give details of any practical activities/demonstrations that you carry out as well as the resources, i.e. chemicals/substances you use.

(b) What kinds of practical activities do you carry out with your learners to show that carbon dioxide gas is acidic? Give details of the resources you make use of, i.e. chemicals/substances.

(c) What kinds of practical activities do you carry out with your learners to show that carbon dioxide gas does not support combustion? Give details of the resources you use, i.e. chemicals/substances.

(d) What kinds of practical activities do you carry out with your learners to show that carbon dioxide is a greenhouse gas and contributes to global warming? Give details of any practical activities/demonstration carried out as well as the resources, i.e. chemicals/substances.

(e) How were you taught about carbon dioxide gas in nature in terms of the processes of respiration and photosynthesis? Give details of any practical activities/demonstration carried out as well as the resources, i.e. chemicals/substances

8. What factors enable or constrain you in teaching the topic on formation of carbon dioxide gas?

(a) Factors that enable you in teaching the topic on formation of carbon dioxide gas.

(b) Factors that constrain (limit) you in teaching the topic on formation of carbon dioxide gas.

Appendix B2: Questionnaire (collated responses T1 to T21)

1. Part A: Bibliography information

Code	Gender	Highest qualifications	Qualification in Physical Science	Teaching experience in Physical Science (years)	Age group	Position
Category 1: Physical Science teachers						
T1M	M	ACE/FDE	ACE/FDE	5	26-30	Teacher
T2M	M	FDE	FDE	10	36-40	Principal
T3M	M	ACE/FDE	ACE/FDE	5	36-40	Teacher
T4M	M	ACE/FDE	ACE/FDE	7	31-35	Teacher
T5M	M	BETD	BETD	4	26-30	Teacher
T6M	M	ACE/FDE	BETD	1	26-30	Teacher
T7F	F	ACE/FDE	BETD	7	26-30	Teacher
T8M	M	ACE/FDE	ACE/FDE	2	26-30	Teacher
T9F	F	ACE/FDE	ACE/FDE	5	31-35	Education officer
T10F	F	ACE/FDE	ACE/FDE	9	31-35	Teacher
Category 2: Teachers for either Biology/Life Science/Natural Science/Agriculture / or have assisted with Physical Science teaching						
T11F	F	ACE/FDE	None	None	31-35	Teacher
T12M	M	BETD	None	None	31-35	Education officer
T13M	M	ACE/FDE	None	2	26-30	Teacher
T14M	M	ACE/FDE	None	3	3	Teacher
T15M	M	ACE/FDE	None	None	20-25	Teacher

T16M	M	ACE/FDE	None	4	36-40	Teacher
T17F	F	ACE/FDE	None	4	26-30	Teacher
T18F	F	ACE/FDE	None	None	26-30	Teacher
T19F	F	ACE/FDE	None	2	26-30	Teacher
Category 3: Teachers who are only teaching Mathematics						
T20F	F	ACE/FDE	None	None	26-30	Teacher
T21M	M	ACE/FDE	None	None	31-35	Teacher

2. **Part B: Responses to questions**
   Question 6: Experiences on having been taught the topic formation of carbon dioxide

Code	**6 (a) How you were taught the preparation of carbon dioxide gas in the laboratory/classroom? Give details of any practical activities/demonstrations used as well as resources, i.e chemicals/substances.**
Category 1: Physical Science teachers	
T1M	CO_2 is produced by reacting marble chips with dilute hydrochloric acid. Calcium carbonate.
T2M	By providing the chemicals such as calcium carbonate and dilute hydrochloric acid when these chemicals are reacted, they produce a salt and carbon dioxide.
T3M	Use/react an acid with a carbonate and collect it using a downward method because carbon dioxide is heavy
T4M	Carbon dioxide is produced by the decomposition of calcium carbonate done by heating it with a burner. This heating produces calcium oxide and carbon dioxide. Also, carbon dioxide is also produced by reacting calcium carbonate with an acid
T5M	I was taught that calcium carbonate can be decomposed through decomposition process to give calcium oxide and carbon dioxide. $CaCO_3$ can be heated in the test tube using a candle
T6M	I cannot recall this
T7F	Using calcium carbonate (heated) as well as fermented Oshiwambo brew
T8M	A beetle was used and placed in a sealed container for days for it to respire
T9F	I once remember that we were taught that if you have calcium carbonate, you can produce carbon dioxide

T10F	A practical activity was carried out in the laboratory. We have burnt fuels to produce carbon dioxide. We have also reacted acids and carbonates eg. Hydrochloric acid reacting with calcium carbonate
Category 2: Teachers for either Biology/Life Science/Natural Science/Agriculture / or have assisted with Physical Science teaching	
T11F	I was not exposed to this topic
T12M	From the biological perspective, carbon dioxide is produced as a result of the break down of glucose during respiration. It is also released from decomposition of plant and animals (living organism)
T13M	By blowing into a container
T14M	By using calcium carbonate with dilute hydrochloric acid and also by blowing through
T15M	We did an experiment of whereby we use $CaCO_3$ powder and mix it with water then shake and filter the water then take a blowing straw to blow in the air and if the water turns milk white, then there is a presence of CO_2
T16M	Burn carbonate
T17F	From the breaking down of plants and animals during decomposition
T18F	Burning wood, fermentation
T19F	Burning wood
Category 3: Teachers who are only teaching Mathematics	
T20F	No response
T21M	Calcium carbonate + acid

Code	**question 6 (b)How were you taught that carbon dioxide gas is acidic? Give details of any practical activities/demonstrations carried out as well as the resources i.e. chemicals/substances**
Category 1: Physical Science teachers	
T1M	It cause sour taste when dissolved in water. The solution of CO_2 turns a blue litmus paper red. Cause acid rain.
T2M	It was talk that too much carbon dioxide in the atmosphere dissolves in rain water and fall as acid

T3M	If you dissolve carbon dioxide in water, it will cause water to be acidic, Calcium Carbonate react with hydrochloric acid. water trough, delivery tube, test tube, stopper
T4M	Carbon dioxide is acidic because it turns a dump litmus paper red. To test this, one has to wet the litmus paper and move it above the burning fuel (wood) and it would turn red
T5M	It was taught that CO_2 dissolves in H2O turn water in acidic thereby turning blue litmus paper to red litmus. You can full a test tube with water at one quarter (1/4) and insert a blue litmus paper into water take a straw and bubble the gas from your mouth into water, the litmus paper will turn to red
T6M	I was taught that CO2 is acidic that is why human beings release it out instead of breathing it in.
T7F	I was not taught that carbon dioxide is acidic
T8M	No response
T9F	It was just theoretical that it was an acid and I drill it in my mind
T10F	When carbon dioxide is dissolved in the water, the solution will turn a blue litmus paper red, which simply shows that the solution is acidic.
Category 2: Teachers for either Biology/Life Science/Natural Science/Agriculture / or have assisted with Physical Science teaching	
T11F	I was not exposed to this topic
T12M	No idea
T13M	Because it cause acid rain
T14M	I cannot remember
T15M	I can't recall
T16M	No response
T17F	No response
T18F	CO2 dissolve in water and can cause water to become acidic
T19F	Because it taste sour and its normally used in brewing products
Category 3: Teachers who are only teaching Mathematics	
T20F	No response
T21M	When it gets too much in the atmosphere, it causes acidic rain

Code	6 (c) How were you taught that carbon dioxide gas does not support combustion? Give details of any practical activities/demonstrations carried out as well as the resources i.e. chemicals/substances
Category 1: Physical Science teachers	
T1M	A candle burning under an inverted jar goes off after a while. This indicates that oxygen is finished and carbon dioxide could not support combustion.
T2M	By using burning splint, it brought the container that have carbon dioxide it will dim, which indicates that it does not support combustion
T3M	It put off the fire, test tube, calcium carbonate hydrochloric acid, delivery tube, candle, react the acid with calcium carbonate, collect the gas into a delivery tube quickly put the mouth of the test tube on the flame of a candle and flame will go off.
T4M	Carbon dioxide stop burning and it is experimented by placing a burning candle in the jar of carbon dioxide and you would expect the light to go off
T5M	By invert two equal sized candle with two different sized container over those two candles. The small container will trap little amount of oxygen inside in in comparison to the large container. When the oxygen amount in the trapped environment finished, the candle will go off automatically. Therefore, the candle inverted in the small container will go off first because only CO_2 will be available.
T6M	If you take a glowing stick in a test tube containing CO2, it will automatically go off
T7F	By putting off the fire/flame on the candle when breathing
T8M	No response
T9F	Experiment was done in the lab whereby two test tubes (one for CO_2 and the other for CO2). Oxygen relight a glowing splint while carbon dioxide did not
T10F	It was taught that it does not supports burning because it used to put off fire. A demonstration was carried out by the teacher where she has used a small laboratory extinguisher to put off the fire.
Category 2: Teachers for either Biology/Life Science/Natural Science/Agriculture / or have assisted with Physical Science teaching	
T11F	I can recall a certain experiment that we did at secondary, we did the experiment to test if carbon dioxide supporting combustion. There were two test tube one is for carbon dioxide and the other one is for oxygen, the one for carbon dioxide and the other one is for oxygen, the one for carbon dioxide make the light to go off and the other one for oxygen make the fire light up.

T12M	This was taught by a demonstration of a growing stick, which grow off quickly when exposed to carbon dioxide, unlike when expose to oxygen.
T13M	It was never taught above
T14M	By the use of burning candles and a jar which is placed on them
T15M	It is only oxygen that support combustion
T16M	It extinguishes fire
T17F	I can't recall
T18F	It does not support combustion because it is used in fire extinguisher
T19F	It does not support combustion, because it contain carbon element that extinguishes the fire
Category 3: Teachers who are only teaching Mathematics	
T20F	No response
T21M	By lit splint and put it in the tube then it will go off
Code	**6 (d) How were you taught that carbon dioxide gas is a greenhouse gas and contributes to global warming? Give details of any practical activities/ demonstrations carried out as well as the resources i.e. chemicals/substances**
Category 1: Physical Science teachers	
T1M	No response
T2M	Practical which I know was on collecting carbon dioxide in jar which container clear lime water which in return carbon dioxide turns clear limewater milky.
T3M	No response
T4M	It behaves like a greenhouse (made of glasses) that allows heat to come inside it but does not allow to escape back into the atmosphere
T5M	Carbon dioxide can be discovered by bubbling an unknown gas in limewater, if this gas is carbon dioxide, limewater will turn milky.
T6M	I cannot remember this
T7F	Not taught how to test carbon dioxide as a greenhouse gas
T8M	No practical activity was done

T9F	It was just theoretical that CO_2 is a greenhouse gas. The test for CO_2 was anyway taught with limewater and straw. Experiment was done as we were asked to blow into limewater and it turned milky
T10F	No response
Category 2: Teachers for either Biology/Life Science/Natural Science/Agriculture / or have assisted with Physical Science teaching	
T11F	I was not exposed to this experiment
T12M	The accumulation of carbon dioxide in the atmosphere prevent the escape back in the atmosphere.
T13M	No response
T14M	I cannot remember on how to test carbon dioxide is a green house
T15M	I can't recall
T16M	No response
T17F	CO_2 is a greenhouse gas from the burning of fossil fuel. No practical was carried out.
T18F	Too much carbon dioxide (CO_2) in the atmosphere leads to global warming
T19F	It is a green gas because it trap heat energy from the sun by trapping too much heat from the sun increases the earth temperature which is a condition called global warming
Category 3: Teachers who are only teaching Mathematics	
T20F	No response
T21M	I cannot remember

Code	**6 (e) How were you taught about carbon dioxide gas is nature in terms of the processes of respiration and photosynthesis? Give details of any practical activities/demonstrations carried out as well as the resources i.e. chemicals/substances**
Category 1: Physical Science teachers	
T1M	It is produced during respiration and used by plants in photosynthesis, to make their own food.
T2M	Cannot remember, all I know is that when we breathe in, you take oxygen and breathe out carbon dioxide.

T3M	Human breath out carbon dioxide and plant will use carbon dioxide during the process of respiration. Glucose + oxygen →carbon dioxide + water
T4M	During respiration, carbon dioxide is produced by oxygen and glucose reacts in living organisms. While during photosynthesis, carbon dioxide reacts with water, to produce glucose and water.
T5M	It was said that carbon dioxide is one of the reactant in the photosynthesis and one product of respiration
T6M	Photosynthesis which is a decomposition reaction produces glucose + water + CO2. I cannot recall the whole process very well.
T7F	Taught that carbon dioxide is released during respiration and it is used during photosynthesis
T8M	Carbon dioxide is one of the end product of respiration and it is needed by plants for photosynthesis
T9F	Plants do respiration mostly during the night and produces oxygen. For plants to photosynthesize, there must be CO2. It was also more on theory but we were also required to memorize the equations
T10F	No response
Category 2: Teachers for either Biology/Life Science/Natural Science/Agriculture / or have assisted with Physical Science teaching	
T11F	In terms of natural science, and Health education, we demonstrated about how photosynthesis takes place, CO2 + H2O (sunlight, chlorophyll)=C6H12O6
T12M	Carbon dioxide is a product of respiration during the break down of glucose whereas it is requirement during the process of photosynthesis
T13M	No response
T14M	Was just taught theoretical and some demonstration on the chart
T15M	CO2 is necessary for photosynthesis to take place and plants respire by taking in CO2 & take up
T16M	No response
T17F	In respiration, living things respire carbon dioxide during breathing, and photosynthesis plants use CO2 as a raw material for the process of it, to take place. Resources leaf was placed in the cupboard, for several hours, and left to test if photosynthesis has taken place.
T18F	Plants need carbon dioxide in order to make their own food through the process of photosynthesis

T19F	Yes you put the plant in the dark room and another one in the room where light can penetrate then you will observe that the plant in the dark room will not photosynthesise
Category 3: Teachers who are only teaching Mathematics	
T20F	No response
T21M	No response

Question 7: Your experiences on teaching the topic 'formation of carbon dioxide'.

	Responses to question 7 (a) How do you prepare carbon dioxide gas in the classroom/laboratory with your learners? Give details of any practical activities/demonstrations you carry out as well as the resources i.e. chemicals/substances you use
Category 1: Physical Science teachers	
T1M	By reacting calcium carbonate with dilute hydrochloric acid or by breathing out
T2M	By adding chemicals to dilute acid such as potassium carbonate
T3M	CaCO3, HCl, react the two collect the gas through the delivery tube, invert the delivery tube with carbon dioxide, produced to the flame of the candle, the candle will go off
T4M	In my class, I usually prepare carbon dioxide by decomposing copper carbonate by heating it. Copper carbonate decomposes to copper oxide and carbon dioxide.
T5M	By heat up and decompose calcium carbonate in the set up experiment and collect the gas produced through delivery pipe, for the heated test tube through water into inverted test tube emerged from water
T6M	I did not get an opportunity to carry out this activity in the classroom since I only taught the subject for a lesser period of time
T7F	I prepare carbon dioxide by reacting a dilute HCl acid with calcium carbonate
T8M	We took balloons and each learners blow air in the balloon. We took clear limewater and bubble through the gas. If limewater turns milky then carbon dioxide is produced.
T9F	React calcium carbonate and hydrochloric acid and then carbon dioxide will be produced
T10F	We did it by carrying out practical activities mostly reacting carbonates and acids. We mostly use sulfuric acid, hydrochloric acid and react them with any carbonate. Our laboratory is not very big and thus in many cases we use calcium carbonate.
Category 2: Teachers for either Biology/Life Science/Natural Science/Agriculture / or have assisted with Physical Science teaching	
T11F	I did not do such an experiment
T12M	Do not do this
T13M	No response
T14M	By using diluted hydrochloric acid. By bubbling though lime water
T15M	No response
T16M	No response
T17F	Not teaching it
T18F	No response
T19F	No experience
Category 3: Teachers who are only teaching Mathematics	
T20F	No response
T21M	No response

Code	Responses to question 7 (b) What kinds of practical activities do you carry out with your learners to show that carbon dioxide gas is acidic? Give details of any practical activities/demonstrations you carry out as well as the resources i.e. chemicals/substances you use
Category 1: Physical Science teachers	
T1M	Produce CO_2 by reacting calcium carbonate with dilute hydrochloric acid and bubble it in water or blow in water with a stroke. Test if the solution with blue litmus paper or universal indicator
T2M	By test the solution with formed from carbon dioxide with indicator to determine whether the solution is acidic or alkaline
T3M	Bubble the gas through water, test the water with litmus paper (blue) if it turns red then it is the indication that carbon dioxide turn water to be acidic provided that a pre-test of pure water was carried out
T4M	I move damp blue litmus paper over a burning candle or any burning hydrocarbon and it usually turn red indicating that carbon dioxide is acidic
T5M	I do carry out testing activities to find out whether substances are acidic or basic. I dissolve carbon dioxide in test tube water and put in a blue litmus paper and take another test tube with pure water and put the same litmus paper and compare the change in colour for the two litmus paper.
T6M	Having used the respiration process as an activity, human beings breathe in oxygen and breathe out CO_2, carbon dioxide has to be breathed out because it is acidic. If you place a living organism in a room with no O_2 but only CO_2, it will die.
T7F	Never done it
T8M	No response
T9F	All carbonic acids contain carbon dioxide and a litmus paper can be used. If it turns a blue litmus paper red, it means it is an acid. If red litmus paper turns blue then it is a base.
T10F	We have dissolved carbon dioxide in water which was pure and after we have tested the solution with an indicator it turned into a colour of acids so it forms acidic solution
Category 2: Teachers for either Biology/Life Science/Natural Science/Agriculture / or have assisted with Physical Science teaching	
T11F	Never did it in my classroom
T12M	Do not do this
T13M	No response
T14M	I did not do it with my learners at grade 8 level
T15M	No response
T16M	No response
T17F	No activity
T18F	No response
T19F	No response
Category 3: Teachers who are only teaching Mathematics	
T20F	No response
T21M	No response

Code	Responses to question 7 (c) What kinds of practical activities do you carry out with your learners to show that carbon dioxide gas does not support combustion? Give details of any practical activities/demonstrations you carry out as well as the resources you use i.e. chemicals/substances
Category 1: Physical Science teachers	

T1M	Burn a candle and an inverted jar
T2M	Burning splint testing and result burning splint goes dimmer
T3M	Candle, $CaCO_3$, HCl, test tube, delivery tube
T4M	I use to place a burning candle in a container of carbon dioxide and the expectation is the light go off.
T5M	Put a burning splinter into a test tube containing carbon dioxide, the light will go off as soon as the flame (light) get in contact with carbon dioxide
T6M	Testing a glowing stick in a test tube by introducing CO_2 gas. So it will automatically go off.
T7F	By placing a jar on the burning candle
T8M	The gas used in fire extinguishers is carbon dioxide. This gas is used to put down fire.
T9F	We used it for oxygen test: materials test tube of CO_2, glowing splinter but it did not relight a glowing splinter
T10F	When a glowing splint is introduced to carbon dioxide it will go off. Carbon dioxide is the gas present in an extinguisher and thus used to put off fire.
Category 2: Teachers for either Biology/Life Science/Natural Science/Agriculture / or have assisted with Physical Science teaching	
T11F	I did not do it with my learners
T12M	Do not do this
T13M	No response
T14M	I light a candle, assuming that learners knows that oxygen support burning, then I cover it with a jar to prevent oxygen and keep carbon dioxide
T15M	No response
T16M	No response
T17F	Not doing it
T18F	No response
T19F	No experience
Category 3: Teachers who are only teaching Mathematics	
T20F	No response
T21M	No response

Code	Responses to question 7 (d) What kinds of practical activities do you carry out with your learners to show that carbon dioxide is a greenhouse gas? Give details of any practical activities/demonstrations you carry out as well as the resources you use i.e. chemicals/substances
Category 1: Physical Science teachers	
T1M	I have never done any practical activity on this
T2M	I cannot recall
T3M	No response
T4M	I do no practical but rather explain how it happens
T5M	No response
T6M	No idea
T7F	Never done it
T8M	No response
T9F	I use to teach/drill this theoretically without practical
T10F	No response
Category 2: Teachers for either Biology/Life Science/Natural Science/Agriculture / or have assisted with Physical Science teaching	
T11F	We did not practice such an experiment

T12M	Do not do this
T13M	No response
T14M	Not at my level, grade 8
T15M	No response
T16M	No response
T17F	Not in line with the subject I teach
T18F	No response
T19F	We construct a green house with the available resources and demonstrate
Category 3: Teachers who are only teaching Mathematics	
T20F	No response
T21M	No response

Code	Responses to question 7 (e) How do you teach about carbon dioxide gas is nature in terms of the processes of respiration and photosynthesis? Give details of any practical activities/demonstrations you carry out as well as the resources i.e. chemicals/substances
Category 1: Physical Science teachers	
T1M	CO_2 is produced through respiration and combustion. CO_2 is used in photosynthesis by plants to make their own food.
T2M	I cannot recall
T3M	Using the idea of Carbon from wood or any burning fossil fuel e.g. Coal that it react with oxygen during burn and carbon dioxide will be formed as a product
T4M	I use to teach that the process of respiration happens as glucose in living cells reacts with oxygen to produce carbon dioxide, while photosynthesis carbon dioxide and react it with water to produce glucose in green plants.
T5M	I was taught CO_2 can be used by the plants to make food in photosynthesis process. When oxygen reacted water, glucose the result will be water and carbon dioxide and this is called respiration. Respiration is a source of carbon dioxide.
T6M	For respiration, human use oxygen to breathe in and breathe out CO_2. For plants, they need CO_2 for them to produce oxygen.
T7F	By explaining that carbon dioxide is produced during respiration and it is used in photosynthesis
T8M	No response
T9F	Carbon dioxide us vital for photosynthesis. Photosynthesis absorbs CO_2 and release O2 as a by product. Respiration absorb O_2 and release CO_2. Both photosynthesis and respiration are vital for life.
T10F	No response
Category 2: Teachers for either Biology/Life Science/Natural Science/Agriculture / or have assisted with Physical Science teaching	
T11F	We demonstrated this experiment during the topic of photosynthesis in grade 5 with a basic experiment without even a science equation as sunlight + carbon dioxide +water =oxygen + glucose
T12M	Do not do this
T13M	No response
T14M	Laboratory equipment
T15M	No response
T16M	No response
T17F	Not in line with the subject I teach
T18F	No response

T19F	It's produced during respiration process and its used during photosynthesis
Category 3: Teachers who are only teaching Mathematics	
T20F	No response
T21M	No response

Question 8: What factors (would) enable or constrain you in teaching the topic on formation of carbon dioxide gas?

Code	Responses to question 8 (a) Factors that enable you in teaching the topic on formation of carbon dioxide gas.
Category 1: Physical Science teachers	
T1M	Our school have enough materials such as apparatus and chemicals
T2M	Available resources within the working environment
T3M	Burning of fossil fuel, e.g. wood in our society. The use of limewater and the factor that it turn limewater milky
T4M	It happens in everyday life when preparing fire at home.
T5M	Creativity enables me to teach but insufficient and in most cases unavailability of equipment or instruments to carry out the experiment constrains my teaching
T6M	Availability of textbooks. General knowledge on the formation of carbon dioxide.
T7F	Using local materials available
T8M	No response
T9F	Laboratory equipment e especially for testing and prepare CO2. Environments – leaves when teaching photosynthesis
T10F	The fact that it is not difficult to explain and understand without doing a practical. I just draw the set up of the experiment in a poster and it is what I use to teach them.
Category 2: Teachers for either Biology/Life Science/Natural Science/Agriculture / or have assisted with Physical Science teaching	
T11F	No ideas
T12M	Respiration as a topic help me to explain to my learners
T13M	The availability of materials, learners prior knowledge
T14M	How to link it to our daily life or natural materials from the environment to use
T15M	No response
T16M	No response
T17F	Not in line with the subject I teach
T18F	No response
T19F	No experience
Category 3: Teachers who are only teaching Mathematics	
T20F	No response
T21M	No response

Code	Responses to question 8 (b) Factors that constrain (limit) you in teaching the topic on formation of carbon dioxide gas.
Category 1: Physical Science teachers	
T1M	Shortage of time
T2M	Shortage of chemicals
T3M	Carbon dioxide is invisible therefore if the reaction failed, it will be difficult to prove whether carbon dioxide is produced or not
T4M	It is not visible for learners to see it and get the reality of how carbon dioxide is formed.

T5M	Physical environment of the class. Unavailability of science labs at school
T6M	Lack of chemical/substances and definitely the lack of a proper functioning laboratory at the school.
T7F	Lack of environment to conduct experiments
T8M	Learners' prior knowledge
T9F	Lack of laboratory equipment for testing and prepare CO2 because sometimes the laboratory runs out of equipment. Sometimes I lack creativity and motivation to use materials from environment.
T10F	Lack of materials in the school laboratory as well as the chemicals. The school laboratory is not in existence and thus not easy to carry out practical in the classroom.
Category 2: Teachers for either Biology/Life Science/Natural Science/Agriculture / or have assisted with Physical Science teaching	
T11F	I did not teach such a topic because it is not at their (my learners) level of study
T12M	Nothing
T13M	Lack of materials
T14M	No response
T15M	No response
T16M	No response
T17F	Resources. Lack of subject content
T18F	No response
T19F	Teaching aid, time, content
Category 3: Teachers who are only teaching Mathematics	
T20F	No response
T21M	No response

Appendix C1: Worksheet 1

Name: ……………………………………………………………………………………………

Hands-on, minds-on and words-on activity 1

1.1 Preparation of the traditionally brewed non-alcoholic *Oshiwambo* beverage called *Ontaku/Oshikundu*

Ingredients and apparatus/equipment needed:

- *Omahangu* flour
- Flour from *Omahangu*/Sorghum germinated seeds
- Residue from already fermented *ontaku/oshikundu* called *oshipithitho*
- Hot water (just below boiling point)
- Cold water (at room temperature)
- Bucket
- Plastic bottles x 4
- Baloons x 4

Procedure

1. Take a generous amount of Omahangu flour and put it in a bucket
2. Boil about 2 litres of water in a kettle and allow it to cool down slightly so that it is just hot enough
3. Pour the hot water in the *Omahangu* flour in the bucket and stir continuously to form a evenly mixed paste
4. Pour about two hands full of the germinated *Omahangu* or germinated sorghum flour
5. Stir continuously until the paste is evenly mixed
6. Continue to stir continuously until the paste reaches room temperature
7. Add cold water (at room temperature) to dilute the paste until it forms a dilute mixture of preferred thickness
8. Pour approximately equal volumes of the dilute mixture into four containers of approximately equal volumes
9. Prepare four different samples (**A, B, C, D**) of the *Ontaku/Oshikundu* as follow:
   A. Ontaku/Oshikundu with Oshipithitho and leave it at room temperature (*control*)
   B. Ontaku/Oshikundu without Oshipititho and leave it at room temperature
   C. Ontaku/Oshikundu with Oshipithitho and put it in a refrigerator (or allow it to overnight in a cold place outside the room)
   D. Ontaku without Oshipithitho and put it in a refrigerator (or allow it to overnight in a cold place outside the room)
10. Once all the four samples of Ontaku/Oshikundu have been prepared, put a deflated balloon on the mouth of each bottle **A, B, C, D** and leave it over night (or approximately 5 hours) for further observations the following day. Take pictures of the samples.

Predictions and explanations for predictions

- First *individually*, then *in groups*, predict what you would observe in each of the samples of *Ontaku/Oshikundu* **A,B, C and D** after +/- 5 hours
- Write down explanations for your predictions. What do you think would happen in each sample and why?

	PREDICTIONS	EXPLANATIONS FOR THE PREDICTIONS
A		
B		
C		
D		

1.2 Preparation of yeast and sugar solution

Ingredients and apparatus/equipment needed:

- A plastic bottle (preferably 2 littre)
- Like-warm water
- Yeast sachet
- White sugar
- Brown sugar

Procedure

1. Pour lukewarm water in a container such as a bucket.
2. Add a generous amount of sugar to the lukewarm water (about half a cup)
3. Add one sachet of yeast to the solution
4. Stir continuously until the mixture is evenly mixed
5. Pour the mixture into a 2 little plastic bottle
6. Put a deflated balloon at the mouth of the plastic bottle
7. Observe for about 5 hours

ACTIVITY 3: Eggs in different liquids

What we need:

- About 6 eggs per group
- Vinegar
- Lemon juice
- Coca cola
- 6 x beakers
- Distilled water

What to do?

1. Prepare three containers of vinegar **(V1, V1, V3)** of approximately the same volume
2. Prepare three more containers and put lemon juice, distilled water and coca-cola respectively in each of the containers and the volume should be approximately equal to that of **(V1, V1, V3).**
3. Label the containers as **L (lemon Juice), W (distilled water) and C (coca cola)**
4. Immerse an egg in each of the liquids respectively (**V1, V2, V3, L, W, C).** Write down your predictions and explanations for your predictions in the table below**.** What do you think would happen to the egg in each case **(V1, V2, V3, L, W, C)**?

	PREDICTIONS	**EXPLANATIONS FOR YOUR PREDICTIONS**
V1, V2, V3		
L		
W		
C		

Appendix C2: Worksheet 2

Name:……………………………………………………………………………………….

Continuation of ACTIVITY 2: Preparation of the traditionally brewed non-alcoholic *Oshiwambo* beverage called *Ontaku/Oshikundu*

1. **OBSERVATIONS AND EXPLANATIONS FOR OBSERVATIONS**
   Observe what happens to the samples of *Ontaku/Oshikundu* **A,B, C and D** the following day and write down your observations and explanations, individually and as a group.

	OBSERVATIONS	EXPLANATIONS FOR THE OBSERVATIONS
A		
B		
C		
D		

ACTIVITY 4: The chemistry of Carbon dioxide gas (CO_2)

1. We are going to prepare carbon dioxide gas in 5 ways

1. From the *Ontaku/Oshikundu* practical activity (Activity 2)
2. From exhaled air
3. From reaction of vinegar and bicarbonate of soda ($NaHCO_3$);
4. From heating baking powder ($NaHCO_3$)

2. Test for carbon dioxide using lime water

We are going to bubble the carbon dioxide in each of the cases 1-4 above through clear limewater

Predictions	**Explanations for your predictions**
Observations	**Explanations for your observations**

3. Investigating the pH nature of carbon dioxide

What we need:

- Tap water
- Test tubes
- Universal indicator solution
- Drinking straws

Procedure

1. Pour water in a test tube and predict what the colour change would be if universal indicator drops are added to the water. Write down explanations for your predictions.
2. Add 2-4 drops of universal indicator solution to the water in the test tube. Make observations and write down explanations to your observations

Predictions	**Explanation for your prediction**
Observations	**Explanation for your observation**

3. Predict what would happen if you take a drinking straw and blow exhaled air through the mixture of tap water and universal indicator solution. Write explanations for your predictions.
4. Take a drinking straw and blow exhaled air through the universal indicator and water solution prepared in number 1 above.

Predictions	Explanation for your prediction
Observations	**Explanation for your observation**

5. **GROUP ACTIVITY: SCIENTIFIC CONCEPTS**
   In your groups, write a **mind map** to indicate as many **scientific concepts** as possible that are associated with the *Ontaku/Oshikundu* ; test for carbon dioxide, pH nature of carbon dioxide practical activities.

Appendix C3: Worksheet 3

Name: ………………………………………………………………………………

ACTIVITY 4: The chemistry of Carbon dioxide gas (CO_2) (continued)

1. **Investigating carbon dioxide and combustion**

We are going to prepare a carbon dioxide atmosphere in a container using vinegar and baking soda.

We are going to bring a burning splint in contact with the carbon dioxide atmosphere.

We are also going to bring a burning magnesium ribbon in contact with the carbon dioxide atmosphere.

A burning splint in contact with CO_2 atmosphere	**A burning magnesium ribbon in contact with CO_2 atmosphere**
PREDICTIONS	**PREDICTIONS**
EXPLANATIONS FOR PREDICTIONS	**EXPLANATIONS FOR PREDICTIONS**
OBSERVATIONS	**OBSERVATIONS**
EXPLANATIONS FOR OBSERVATIONS	**EXPLANATIONS FOR OBSERVATIONS**

ACTIVITY 3 (continued)

Observe **(V1, V2, V3, L, W, C)** for the next **two to three days** and write your observations and explanations for the observations in the table below.

What you need:

	OBSERVATIONS	**EXPLANATIONS FOR YOUR OBSERVATIONS**
V1, V2, V3		
L		
W		
C		

Eggs and hydrochloric acid

Predictions	Explanations for predictions
2 Immerse and egg in hydrochloric acid solution and make observations. Also explain your observations.	

Observations	Explanations for observations.
3 3 Are there any similarities or differences between the effect of vinegar on eggs and the effect of hydrochloric acid on eggs? Explain in detail.	

ACTIVITY 5: Effect of different solutions on eggs and potatoes

After two to three days, take the eggs from **V1, V2, V3** and place them in three different solutions/liquids. You are also going to prepare three pieces of potatoes of approximately equal sizes which are also going to place in three different solutions/liquids.

Label the containers as **Salt sol.'; Sugar sol.; and Water**. Prepare two containers for each solution/liquid. Put an egg and a piece of potato in each of the containers.

1. Concentrated salt solution (salt sol.)
2. Concentrated sugar solution (sugar sol.)
3. Distilled water (water)

Write down your predictions and explanations for your predictions. What do you think will happen to the potato and egg in each liquid and why?

	PREDICTIONS	**EXPLANATIONS FOR PREDICTIONS**
Salt sol.		
Sugar sol.		
Water		

Appendix C4: Worksheet 4

NAME:……………………………………………………………………………………………….

ACTIVITY 6: Hydrogen and Carbon dioxide gases

What we need:

- Caustic soda (sodium hydroxide) and aluminium foil to prepare hydrogen gas
- Using exhaled air to prepare carbon dioxide gas (alternatively use from the Ontaku/Oshikundu experiment)
- Baloons
- Plastic bottles

Procedure

1. Prepare hydrogen and carbon dioxide (**A,B**) gases as described above and inflate three balloons respectively with these gases
2. Observe and compare the three balloons (**A,B**). Write your observations in the space below
   ………………………………………………………………………………………………………
   ………………………………………………………………………………………………………
3. Introduce a burning candle to each of these balloons. Write down observations and explanations for the observations

	Observations	**Explanation for the observations**
A		
B		

ACTIVITY 7: TEA BAGS

What you need:

- Tea bags
- Hot water (boiling point)
- Cold water (preferably from the refrigerator)

You need to put cold and hot water of approximately equal volume respectively in two different containers

You need to put a tea bag in each of the container

Write down predictions and explanations for the formation of colour in the water.

Also write down observations and explanations for the observations

Tea bag in cold water	Tea bag in hot water
Predictions	**Predictions**
Explanations for predictions	**Explanations for predictions**
Observations	**Observations**
Explanations for observations	**Explanations for observations**

ACTIVITY 8: The cooldrink cans!

What you need:

- Cool drink cans (preferably 340 ml or bigger)
- A source of heat (methylated spirits)
- A cold water bath

What to do:

1. Place a small amount of water in the can (enough to cover the bottom of the can) and heat it on the heat source until it start to boil.
2. After one to two minutes of boiling, quickly take the can off the heat source, be careful not to burn) and immerse it in water (upside down) as fast as you can.
3. Write down your predictions, explanations for predictions, observations and explanations for your observations in the table below

PREDICTIONS	EXPLANATIONS FOR PREDICTIONS
OBSERVATIONS	**EXPLANATIONS FOR OBSERVATIONS**

ACTIVITY 9: Washing powder, Nail polish remover and Baking soda

What you need

- Baking soda
- Washing powder
- Nail polish remover
- Cotton wool
- Tap water

What to do:

1. Put about two tea spoons of washing powder in the palm of your hand and clutch into a fist. Immerse your fist in cold water. How does your hand feel? Write down your observations and explanations below.

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

2. Put about two tea spoons of baking soda in the palm of your hand and clutch into a fist as you did in 1 above. Immerse your fist into cold water. How does your hand feel? Write down your observations and explanations below.

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

3. Take a little piece of cotton wool and soak it into nail polish remover. Wipe your skin with it. How does your skin feel? Write down your observations and explanations for your observations.

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

Appendix D1: Interview transcript for teacher 1 (IT1F)

Me: Aaaa.. Ms…. good evening?

IT1F: Eeee

Me: How are you?

IT1F: Very fine, how are you?

Me: I am doing fine thank you

Me: It is very nice talking to you and first of all I would like really to thank you for agreeing to… during this busy time of the studies and you really sacrificed to spend some few minutes with me just for us to discuss regarding the activities that took place this week.

Now what is so interesting, I just want, I know we had an informal discussion in the class on Monday evening of which you stated to me that you teach both Mathematics and Physical Science …

IT1F: Jaa, I can still remember because that thing still troubling me I just want to know why mostly I have experienced it in grade 10 because when I started teaching that is where I started… I did this practical for reflection of light… we have to use the light from the torch and have the paper and drawing those angle of incidence, angle of reflection and so on, just for them to recall that law of reflection….

perception before intervention was that practical activities make learners fail. When she teaches theoretically, learners pass with flying colours.

Me: Eheee…

IT1F: Now, we did that one, then I explained on the board… I was expecting that one now to get that one that if you are having this angle and this angle, they are equal because we even using the protractor,

Me: Eheee….

IT1F: When I asked in the test, they did not performed well…. Because they were just supposed to complete it and… iyaa…

Me: ahaa…

IT1F: and the other one is for… is electromagnetism when you have to use the motor aaand

Me: ooooh electric…

IT1F: electromagnetic induction

Me: Ahaaa,

IT1F: where you have to use the coil and the magnet into…. Iyaa, like that…

Me: Iyaa yes, I remember it….

IT1F: You know that that ka needle have to deflect like to the right and to the left

Me: eeh eh eh… depending on the…the changes of directions yeees

IT1F: iyaaa….We did that one, again in the test and examination …

Me: they did not perform well,

IT1F: They did not perform well, that's why from there, aaaa, even with grade 8, that year I found this potassium permanganate, then you have to test this oxygen, then I wanted them to recall now the testing of oxygen, it relights that glowing splint because they can see when we put that one in, nothing happens, they did not pass

Me: mmmmh

IT1F: They did not pass oshili, that's why from there, I leave it out that….I only teach it theoretically, but they do pass

Me: but they do pass?....

IT1F: They do pass…

Me: Okay, that is so fascinating… and I have been really thinking about you and I thought maaaaan, let me try to.. to.. to.. to just talk to you, so that we just have a discussion regarding what happened aaaa this week

IT1F: mmmmh

Me: then, on that note then I just want to… just to get your feelings and experiences of what we did this week from Monday up to today's activities….

IT1F: What we did this week, I have learned a lot…. Now I am remembering now the activity that we have done that one for caustic soda and the Magnesium, I mean the Aluminium foil,… I didn't know that Aluminium can react like that…. Because I thought, in the foil, they add something so it was even new to me to hear that that Aluminium can behave like a base and can also behave like an acid…. I only saw that one in the question paper that "amphoteric" what what…. But I don't know and I was not even look it up….

IT1F: And the other thing that interest me again was yesterday…. Aaaaa…. Not yesterday…. I don't have my notes now for correction… But I know that I have learned this one for carbon dioxide….

How did you prepare it yesterday?

Me: yesterday…. Yesterday we prepared….

IT1F: Oooo, this one for blowing…. In the kaaaa… in the limewater….

Me: Iyaaa, exhaled air….

IT1F: Because I was only having that you have to produce carb… I did not even know that… that of blowing exhaled air that what is coming out is carbon dioxide…

Me: That is so interesting to hear… That is really interesting to hear…. That some of the activities….

IT1F: [redacted]… while you can just get them in everyday [redacted]

Me: it will be ready (laughing)

IT1F: Sometimes I think we really need to be creative in order to….

Me: No I am so happy to hear that… I am so happy to hear that …. Especially that you are able even to remember some of the specific activities that we did.

Me: So I would like then maybe to ask a follow up question on that, that from those these activities that we did, this week, are there some that you remember doing at college, or university, or school….

IT1F: College…. College…. Shuuuu! I can't remember any kaa…. Of whatever we did there….

Me: hmmmm

IT1F: Because this physical science I only did it at College… and I did not do it anymore…

Me: Iyaa, ooo you did it at school and then at the college, but from what we did from that Oshikundu and you said exhaled air and …you don't…

IT1F: I don't remember kaa….

Me: Okay that is really good to hear…

Me: And you mentioned… maybe I should also do a follow up… you mentioned something like… eeehh so you really feel that what we did this week you feel that we can try some….

IT1F: Not I think, I will do it… Iyaa, that is a fact, I will do it…

Me: Okay…. (laughing), that is soooo fascinating to really hear…feedback from our colleagues….

IT1F: I really enjoyed these lessons…. Because I don't even know how the time went.

Me: so fast… (laughing), Okay maybe another thing I would like to ask is about strategy, the teaching strategy… The approach itself… what is your comment on the approach…

IT1F: That one is also good… because sometimes now when we do the things, maybe the experiment, not only experiment but even in our teaching, we don't do that one like giving time to the learners to think about that… Just pose a question, and ask few minutes, the learner you expect them to give answers, that is why sometimes you find that you are asking a question, the learners are just looking at you, in the process you might just end up your own… answering yourself…

Atalah et al (2010)-indicators of conceptions and dispositions

IT1F: I like that approach like you have to predict and this thing of group work… so when they have to discuss and… that thing eeee, is nice. I think is good,

but again there can be some limitations,

Me: I would really like to hear that…

IT1F: Time because if you…. Think that you give that learners to explain or to discuss in their groups, and tell you something again what they have discussed, by the time they finish, you may not have time to… even give the summary…

Me: ooo… jaaaa, you were talking about the time… iyaaa,

IT1F: Like me, I like giving summaries to my learners… because I think that when they are, when they have that summary, they are able to learn something…

Me: To learn something… Ahaaaa

IT1F: And again the number of learners that you are having….They may not give us that opportunity to have all of them give their views for example you are having a class, like now in grade 9 we are having 42 just in one class, so iyaa….

Me: Iyaa, so I really like, what I like about your articulation and your openness is that you are looking at both what went right and some of the challenges. I really like that… Because for us really to improve, we need to look at both sides,

IT1F: Yes because it is not always successful, it might be successful here, but when you go there it is a different story… or maybe because these teachers they know what they are doing already, they have they know that one exactly, but the learners it might take them longer time to…digest everything and… give you something…

Me: yes I really like that idea of the challenges and those are even things that can help us to improve for the future when it comes to the teaching programs

Me: Iyaa…. So emmmm, I think emmmm, that is really basically it, I just wanted to hear from you, I just want to give you time to give any general comments…

IT1F: This is what I have already said that this week, I really experience science, not just science but in particular specific Physical Science, because I am more on Physical Science, I have majored in Physical Science and Life Science but Life Science is not really my… since I started I did not even try teaching that Life Science

Me: Ahaaaa

IT1F: Mmmm I am more into Physical Science and I learned a lot

Me: So what, when you are using these simple things, do you think when you are looking at our country at large, do you think it is a relevant thing maybe if you are to advise …

IT1F: Is not irrelevant because now you don't need to put the pressure like some schools they are experiencing financial problems so instead of like ordering like… I was making a quotation at.. I checked Nehale SSS when we make their quotations from medlab

Me: From medlab, yeees,

IT1F: It was expensive like our school it cannot just afford that, we cannot afford because our learners they are paying like 200 per year… Now looking at that cost, the one that we have to pay in order to get those equipment or chemicals, you cannot afford, but when you are using these cheap materials, or everyday material, I think it is really working because it is the same thing, only the chemical that are being iyaa, you don't need to spend much like the vinegar… How much is the vinegar in the shop,

Me: Some you buy, some you get, like the joke we were making in class that Aluminium foil even after a wedding, you can pick up…

IT1F: you have it already then go and but the new one... is very nice that we can use those materials that are available in our environments… it makes it very easy and the learners need to know that this is all what you need… you don't need to go and buy something else….

IT1F: Iyaa, exactly….

Me: thank you very much that you were able to share your experiences of the week especially that you pointed out on the positive as well as on the challenges where we can try to look at… I really like that… because there is nothing that is 100% perfect….so thank you so much….

Appendix D2: Interview transcript for teacher 2 (IT2M)

Me: Good evening?

IT2M: Good evening madam?

Me: How are you?

IT2M: I am fine how are you?

Me: I am doing fine.

Link responses to research questions

Aaaa… First of all I want to thank you for really agreeing to discuss with me just regarding the science activities that we have been having this week from Monday up to today. So I just want to hear some opinions and some experiences from you regarding this. Okay, maybe first of all I should ask, eeehhh, from the activities that we did, say from Monday up to today, are there some of them that you have already done before?

IT2M: eeh, since I am a new Physical Science teacher, I normally teach Mathematics, most of the activities I did not did them, maybe the only activities that I did is the one I did when I was a student.

Me: Ahaaa, ahaaa, when you were a student… okay. So… so you did science at tertiary?

IT2M: Yes I did science at tertiary, the activities that we did this week that we did at tertiary is like the testing of carbon dioxide, the testing of hydrogen, and… iyaa those are the most activities that we did… we used to do at tertiary education.

Me: I am very happy that you pointed out the testing for carbon dioxide, the testing for hydrogen. Okay, let me do a small follow up on that… for example this week, we made use of the Oshikundu, we make use of vinegar and baking soda, and we also made use of the air that we breathe out… that is all for carbon dioxide… so when you were at tertiary, did you use exactly those experiments?

IT2M: Not really exactly because how our gas was prepared here they were prepared from our everyday material but at tertiary there we were having a fully equipped laboratory so we were more on the things in the laboratory

Me: Ahaaaa, so the chemicals that are recommended…

IT2M: Jaa the chemicals which are recommended, for example like the carbon… like when you are coming up with carbon dioxide… test for carbon dioxide..

Me: Yes I do understand your view that you were using the chemicals that were provided in the laboratory and I do get your idea that you had well resourced laboratories at tertiary….

IT2M: And there was also like a guidance that for this one you must use this, for this gas you must use this chemical to come up with the gas, all the procedure how to come up with the gas was already there written (question 1 and 2)

Me: Ahaaaa, okay okay I am very happy to hear that.... So because you are telling me that the chemicals are already said use hydrochloric acid or sulfuric acid or whatever chemical to prepare...

IT2M: eeeee... (yes) (question 1 and 2)

Me: so I am glad to hear that you have tested for the gas but the difference is just that what you have used is not necessarily what we used this week, but you did it...

IT2M: Yes

Me: okay good! Then, maybe to ask more, how, how do you feel about this compared to how you did at tertiary institutions using those chemicals in the laboratory like the acids and then compared to using everyday material .. how do you feel about this... using everyday material...

IT2M: **This is wonderful for everyday material because at tertiary education, you are being taught to go and teach at different schools, and if you are only taught using regular materials, those materials you may not be having them at your school so using everyday material it helps you to prepare the gases like the one we were testing or to, it helps you to carry out different investigations regardless of the availability or unavailability** of the materials because those materials you can buy them some from the shops... some you can just prepare them from everyday material that you use home, from what learners use home...

Me: Okay, I am very happy to hear that and I like your point of saying you are prepared at tertiary institution and you are going to teach at different schools and that not all the schools will be well equipped like it was the case at tertiary... I am very happy to hear that.

Okay, form one interesting conversation I had with you in January which made me to be so interested in talking to you after this is when we had a telephonic conversation of which you said aaaa I am only teaching Mathematics, if I can take even just one class for Physical Science, then I also supported your thinking that yes I think if it is possible, to get a class from your principal, it will really benefit you a lot, so how do you feel about teaching that grade 8 class?

IT2M: Okay, teaching science is, it is wonderful. I got to love it, teaching science, because I was used to be more on Mathematics... For science there are a lot of practical activities that you can do with the kids there are a lot of things that you can ask kids to observe in their houses so I really like it teaching science and I hope I will not stop teaching it after the studies, that is my hope.

Me: I am so happy to hear because you have now only taught it for three months and I am so happy to hear that you are really enjoying. So, from what we have just done, the little activities that we have just covered, do you think there are some which might be relevant to your teaching when you go back?

IT2M: Iyaa, most of them they are relevant and some of them the topics I already taught them, like we were dealing with kinetic theory of matter, whereby it involves particles, moving, gaining energy, so, like the activity that we did on Thursday was more interesting whereby we were having two tea bags, one is in warm water, one is in cold water, so when the one in hot water when of course, the particles there they are gaining heat energy being converted into kinetic energy then they will start moving quickly compared to the one in the cold water. So it was the good example to use like when I was teaching that topic. So I will take note of that one, so I will try to use it next year when I am going to teach that topic again.

Me: Okay, I am very very happy to hear that you can even narrate and recall, so I am very glad to hear that some of the activities will, and by pointing out a specific activity that could be useful to the learners… Even the one that, of producing gases, because most of the teachers, we know that, we know how to test carbon dioxide, aaa, we know maybe the material for testing carbon dioxide, and also hydrogen, but we don't have the gases at our school and we don't have the material to come up with those gases. So this activity, this was interesting for us to learn, how to come up with those gases…

Me: Ahaaa! No I am very happy to hear that. Okay, Maybe I would also like to hear mmm, your opinion about the approach, the approach, just general, the approach, how we carried out the activities… Like maybe if I… I don't know whether my question is clear, the whole approach…

IT2M: Okay, yes, the activities, the way you carried out the activities was quite good but with the time, I don't know if I should also put time there…

Me: Yes yes you are welcome…

IT2M: I think you did not have enough time to carry out all the activities because some things were too much together, and sometimes teachers might not get time to recall everything even though they were writing and taking pictures.

Me: Yeeees,

IT2M: Actually the approach, the approach was good if it was done like step by step, one activity per day, then that could be good.

Me: You know, what I like about such reflections for example you pointed out the time, you know, I like that because it is giving us some picture for future that this happened, maybe in future we can do it this way, we can change here and there, so I really like that, the pointing out of that approach… So, aaaah, maybe just to ask a follow up question about the approach, for example let us say testing for carbon dioxide, so, would you prefer for example to first teach the learners theory that carbon dioxide turns limewater milky, or would you prefer to first do an experiment with them and then explain after?

IT2M: Okay for me I prefer practical first, so when teaching that topic, like a practical topic, I can do the activity with the learners first, then the learners will observe what is happening, then after they observed what have, what happened, then I will ask them to write like a conclusion of that one, then is when I will come and teach the topic, not really teaching but just going through what happened because they have already learned it.

Me: Yeees, they have already done the activity and observed, then you are explaining based on what was observed.

IT2M: On what was observed and maybe if there is something which was not clear, then I will make it clear in the process.

Me: Ahaa, I really like that feedback from your side. Soo, aaaa, perhaps, well, I didn't really have, I just wanted some of your insights from that activity, so if you have any other thing to comment on, anything to just make general comments, you are welcome to make some comments.

IT2M: Okay maybe the comment which I can say is I just like the way like the whole thing was prepared. Like the way you give like now since you were doing it with teachers, most of them they are senior teachers, then you ask them first to predict what will happen and most of them their predictions were actually what happened. But with learners still it is okay we can still do that one with learners for them to predict what will happen, and maybe just to encourage them that what you have predicted is not really necessarily that it is what will happen

Me: yeees, ahaa, ahaa, ahaa

IT2M: That one I like it, and maybe the way that I like from you is that you, when you presenting the things, like aaa, caustic soda,

Me: aaa, aaa, ahaaa,

IT2M: You mention like where you bought it because some things we can say they are easily accessible but maybe in the shops that you bought it, we don't have them in the community. But the moment you say you bought this one where and you can find it at this like where it is used in the house also because some things we have them in the house but only people who know the kitchen stuff know those things. Some of us we don't know them.

Me: (laughing) exactly, exactly… noo I am so happy to hear that, I am so happy to hear that…

So, no it was very nice hearing from you, it was very nice working with you, throughout this week. And if it is possible, because we are dealing with the whole class of 25 students but we do need to do a follow up on two teachers, just to, out of the 25. So if you by any means you are willing for us to continue working together, you can always indicate to me.

IT2M: Okay, no you are always welcome to work with me, okay thank you!

Appendix D3: Interview transcript for teacher 3 (IT3F)

Me: Good afternoon…..?

IT3F: Afternoon?

Me: How are you?

T3: I am good and yourself?

Me: I am doing fine thank you. Iyaa, first of all I just want to thank you for agreeing to participate in this research. It is very nice working with you. So the reason why we are meeting this afternoon is just to reflect on some of the activities that we did during the workshop, the practical activities. So in general I just want to find out how did you find this workshop?

IT3F: Okay. Thank you for the question. No the workshop was very I don't even know how to express myself in terms of this workshop because it is very enjoyable, the way I was myself in that workshop I could put myself as a learner because seeing these activities happening, I nearly believed that I am not a teacher myself because it is the activities that some of the I try them using different materials that we have in the lab but now looking at the things that you have tried to use there it is as if I never saw them before. Some of the things are the things that I even have at home, every day I see them some of them I deal with them, I eat them, eggs and Oshikundu things I drink them but then the way you put them up in the way of activities it was really something else for me. It was a good experience, it was an eye opener even because it has opened me to so many things and I am developing so many ideas in terms of doing activities in my class, just from that workshop.

Me: Okay. No I am very happy to hear that so because I just wanted to find out how you found the workshop because sometimes you think that maybe the thing can work but after we have conducted something we still want to find out ideas from the people involved. So I am very happy to hear that you enjoyed the activities. If you can maybe point out to me the most exciting activity, which one could it be maybe.

IT3F: Well, for me, I really do not have one specific activity that I call exciting one so I must say maybe more than 3 of them if not all of them. Because like I said, it is things that I see but now seeing them producing gases, reacting and doing all that for me they are just so exciting. Say for example Oshikundu, I know I like it, I do make it at home, I do not make it to produce gas like I see. Now seeing that they are producing a gas that I am able to see in a container and that I can be able to test, it was an exciting moment for me already. Thinking about the eggs, I know I was taught and I know I talk about it, that egg shells contains calcium carbonate, but now I never just thought of using a weak acid, or even a strong acid to look at now how the egg is being reacting with the acid, so all those things were very exciting, the foil, I used it, I threw it away, I know it is a metal, I talk about it that aluminium can be used for making food containers, foil is one of the examples, but then I never came to an example or idea of taking it as a metal, reacting it with something to produce that hydrogen. So already, even if I know it, it was very exciting moment for me just to test that hydrogen coming from the foil, that I know about, that I see it coming from my kitchen.

Me: Hmmm, no that is very interesting to hear. Okay and then now that question tempt me, I almost wanted to ask that coming to our institution, the way we have been doing these activities in our tertiary institutions when it comes to teaching, whether our lecturers were really including these activities in the lessons? Or they were, what type of practical, what was maybe their main method or the main chemicals that they used at the college or university level.

T3: Okay, to tell the truth, I was long back at the college, maybe I can't remember some but I can't remember of a certain activity that we did at the college that we have used readily available materials. Even now to think about the list of things that we have used in Rundu for those activities, I can't remember my lecturers, science lecturers now having a foil and making Oshikundu in the class. Maybe just talking about them like the weak acids are like vinegar, and now is what you have used to react with the egg shell, the foil is a metal, they are talking about them, but I can't remember seeing them doing practical using readily available material. Else we just used chemicals in the lab.

Me: In the lab, ahaa, that is quite interesting. So to say that like at tertiary institutions, you make use of chemicals in the laboratory without including easily accessible resources in our teaching,

T3: Yaa because even the activity of diffusion, we did the one of gases, I remember we have used the one of ammonia and an acid, and I remember we used diffusion in water where we used the purple potassium permanganate. That is what I use myself and that is what is being used at the college and even at my secondary school. So now seeing a tea bag, it look simple, but it is really something that now opened me that I don't need to worry, if I don't have the potassium permanganate in the lab I can use the tea bags as well. Even coffee, I came to think about even coffee itself, just coffee powder putting it in water, it will definitely behave like a tea bag.

Me: Okay, I am happy to hear that . Maybe the last question that I would like to find out from your experience from the workshop, is maybe to say that as you are interacting with other teachers in the country, do you think that these activities are useful to be used in school. Of course we are doing them in the workshop but do we think that they are also, they can be used in our schools with our learners?

IT3F: Yaa, that is obvious, because if teachers like me are finding it interesting, what do we think about learners? And they can also be, it is good if they can be done in schools because like here, not all the schools are having labs, some schools are having just kits, and is not, is not, science kits, and is not everything that is in there. Some schools curriculum were just extended, they were just having grade 7 and they extended to grade 8 while they did not receive materials,

I mean it will be good if we involve these things in schools because I mean the knowledge that they get is just the same as using chemicals in the lab and it will even make the work for the teacher easier not to wait for the chemicals but then just to get those, even if you send learners themselves, they will bring. Each of you bring me a tea bag, just get me when you have a party or something, bring the foil here, instead of throwing them away. Then activities can happen at school and it will really help the learners. Because now I know, there might be some teachers who are not doing practicals because they don't have chemicals, they don't have materials, but if we introduce such a thing in school, it will really help the people.

Me: Yaa, in case when we have lack of resources.

IT3F: **Even if we have resources, we should introduce the learners to the importance of using readily available materials.** Don't just throw away containers, don't just throw away the egg shells, they also have something useful to do, like to produce a gas.

Me: Okay I like the point that you are bringing that even if there are resources, maybe just to mix okay, sometimes when there are not resources, you use it, even when there are, maybe there is hydrochloric acid but I can buy vinegar,

T3: Iyaa.

Appendix E: Reflection guide and transcript at the end of the workshop (RT1 to RT21)

Reflection guide

1. This week we carried out some practical activities using easily accessible resources. We also had a workshop on assessment for learning (AfL). Do you have any past experiences in these during your schooling/tertiary studies/teaching experiences?
2. What are your views regarding doing practical activities using easily accessible resources/local material?
3. What are your feelings regarding the approach: Predict →Explain→ Explore (practical activity) →Observe → Explain (PEEOE) approach?
4. What are your thoughts toward the use of formative assessment?
5. Has participation in this workshop changed your attitude towards practical activities or not? If so, in which ways? Please explain.
6. Would you recommend the activities and workshops carried out this week to be conducted to other science teachers in Namibia?
7. Any other comments

Reflection transcripts

Code	Responses to question 1 [to answer question 1 and 2] This week we carried out some practical activities using easily accessible resources. We also had a workshop on assessment for learning (AfL). Do you have any past experiences in these during your schooling/tertiary studies/teaching experiences?
RT1	No, my teacher does not normally include practical activity but just focuses on theory
RT2	No
RT3	Yes, during my studies but it was more laboratory based
RT4	Yes, during tertiary studies and teaching experience
RT5	To a certain extent yes, some of the practical I have done them during my teaching, but not as nicely as it was done during the week. The part of assessment was so fascinating.
RT6	Yes, the production of carbon dioxide as well as the brewing of Oshikundu are experienced during the topic of human respiratory system
RT7	Just a bit, especially on tea bags in hot and cold water about diffusion
RT8	No
RT9	A bit of experience especially testing CO_2 using a straw
RT10	I had the experience during my high school
RT11	Yes I had the past experience during my tertiary studies in Biology section. I also had experience of assessment during my teaching experiences
RT12	There is no activity that I can recall and I have never done one with my learners
RT13	Only few experience
RT14	Some of them only, like the preparation and testing of carbon dioxide. I only didn't experience the production of hydrogen from reacting aluminium and baking soda.
RT15	Yes, I have attended some workshops on both practical and assessment

RT16	Yes, a little bit of it and this was necessitated by the lack of resources. I use to do it as a mean of improvising.
RT17	No I did not think brewing traditional beer we could come up with different scientific concepts and also have assess learners. But now I am aware that science is everywhere.
RT18	No, I never had an experience on the kinds of activities. In fact it was really a good learning experience. I could recall some scientific concepts used though.
RT19	Yes, some of the practicals we did were familiar but most of them were not real familiar to me. Formative assessment is something I heard of but I didn't really Implement it in classroom.
RT20	Yes
RT21	Yes during schooling

Code	Responses to question 2 What are your views regarding doing practical activities using easily accessible resources/local material?
RT1	I have realized that I rob my learners to understand the lessons well where they were supposed to fully understand through observation and have longer understanding
RT2	Doing practical activities helps learners to understand and internalize what they are being taught. It helps them to move away from memorizing facts rather than observing and prove at some point to how true or how real are the concepts written in our syllabus
RT3	It is a good thing. Most teachers teach at remote areas where there is no chemicals and science apparatus. It is helpful for teachers to be aware of easily accessible alternatives
RT4	It is cheap and captures learners' interest. It motivate learners to participate and learn from context to content
RT5	It was a very good and enlightening practice to carry out these activities. Many of us (teachers) fail to expose our learners to these activities claiming that there are no laboratories or chemicals at school. While the laboratory is just the very classroom or the open space that nature provided for. The chemicals are just a little finger away from us.
RT6	It is a good idea as it is cost efficient, it uses readily available resources
RT7	It promotes learning and encourage active participation because learners are dealing with materials they are familiar with
RT8	I am seeing it as a wonderful thing to do in a sense that it help learners to create a bridge between their home sciences and the science that they learn at school. Also, it is more cheaper as the resources/materials to be used in the practical activities can be generated from the environment
RT9	It is a very good practice that educators need to improve/implement/empower in our/their teaching practice. It encourage me/gave me insight that although there is no lab at school, I can still use available/cheap materials at home/shops to do practical activities
RT10	It is should be highly encouraged because we have access to all the resources. It is only that we really do not know how to use them in terms of performing practical activities using such resources [PCK – knowledge of the resources]. I am of the opinion that teachers especially the science should receive proper training on how to use easily accessible resources
RT11	Using the easily accessible materials it allows all learners to come along or bring their indigenous resources in the classroom instead of buying it from the shop and some of them they cannot afford it
RT12	It is a great idea because sometimes the teachers do not do practical activities with the reason that there are no chemicals that can be used to carry out experiments. Using local material it gives the teacher and learners a chance to carry out their experiments

RT13	This is a good idea because even if you tell the learners to but it will be easy for them to do it as they are of affordable price. Moreover, they are easy to get as some of them they are using them at home
RT14	It is a powerful form of doing practical activities because it allows learners to get to understand that science is around them.
RT15	It was a good experience, since my school have enough resources, I will refer learners to this simple practical so that they will be able to contextualize their knowledge
RT16	It easily accessible. Learners know it. Learners feel involved in the learning process. It make learners take ownership of their learning
RT17	Very nice and good in the sense that materials or resources does not cost too much to buy them. Moreover, even learners can make them using waste materials and learners will be able to improvise the materials from the waste local environment.
RT18	I feel practical activities should really be re-enforced in classrooms. If eel that they make learning more meaningful and fun
RT19	It is very good because students can easily get them and it is not costly
RT20	Making use of what is part of your context or surrounding for experimenting purposes.
RT21	It is cheap and learners are used for them and get in touch with them

Code	Responses to question 3 [to answer question 3] What are your feelings regarding the approach: Predict →Explain→ Explore (practical activity) →Observe → Explain (PEEOE) approach?
RT1	This is a wonderful approach because it makes me understand better the steps or how to carry a proper lesson where I need to include the prediction explanation and practical activity based on the observation.
RT2	This was a great approach that I could not even use or think of during my teaching. It helped us engage with our thinking abilities and later see how far or close our predictions were to the observations
RT3	The approach was good, predict helps learners to recall what they have already learned. The practical activity will serve as teaching to confirm the prediction.
RT4	It was a good idea
RT5	I like the approach, it encourages engagement in fact. These lessons were the most enjoyable of the session.
RT6	It was an excellent way of teaching learners taught in this way would be given time to think about the aspect/concept before the experiment is done
RT7	It gives room for students to think, question and explore therefore it is a good approach when it comes to practical activities
RT8	It is a great approach as it can help students to move from what they know (based on their experiences) to what they are expected to learn
RT9	It is a good approach helping learners to be engaged fully in the lesson, construct the concepts, observe and drawing up proper conclusions
RT10	This approach will work if a person has prior knowledge on the issue at hand because it would help them to recall. However, starting with predictions could be a challenge to those who do not possess any prior knowledge on the topic under discussion. I suggest to start with exploration → observe →explain
RT11	Based on the prediction it allows me to think critical to what will happen. Practical activity plus observation allows me to prove on what I wanted to find out

RT12	It is a good approach that it gives a chance to someone to think critically if this approach is used to the learners they might learn something in their discussion. However, it is not always an easy task to do, considering the time as well as the number of learners in the class.
RT13	This was a very good feelings as we were given the chance to predict or say what will happen before we observe
RT14	It is a very good approach because it probes critical thinking in learners and can be a better suggestion if everybody else can apply this approach in his/her class
RT15	It is a good approach since it encourages learners' prior knowledge
RT16	It allows learners to think and then later to confirm their assumption. Hence it is indeed an good approach
RT17	This is the best approach so far as learners will be able to correct themselves after the practical activity has been conducted. Moreover, it broadens the understanding of the learners by exploring more
RT18	I enjoyed the predictions part. The prediction part makes learners focus to all the learning activities taking place during the lesson as they would want to see if their predictions work correct
RT19	The approach was good because we had a chance to think for ourselves
RT20	I feel fascinated by this approach as when learners predict it encourage then to enhance their prediction and thinking skills. Learners can also explain by giving multiple perceptions
RT21	It was excellent as it leads learners from what they think of what will happen before practicals

Code	Responses to question 4 [Felisia] What are your thoughts toward the use of formative assessment?
RT1	It is important to check learners' progress and the effective of your teaching
RT2	This is an important aspect in teaching and learning and it helps a teacher to find out whether learning has taken place. By using questioning strategies and feedback.
RT3	Formative assessment helps learners what they fail to understand the concept
RT4	Assessing throughout the lesson
RT5	This is a very critical aspect that teachers do not do in the classroom, where they are doing it, it is not so effectively done, this need to be taken a step further so that teachers understand what formative assessment
RT6	It is a good way of assessing learners progress and it needs to be carried out on a regular base so that the teacher and the learners would be able keep to track of their strength and weaknesses
RT7	It is an important in the learning process
RT8	No response
RT9	It is the fundamental principle of learning. It help the teacher to measure, evaluate the learning process in terms of weaknesses and strengths. I am glad to hear that it is an assessment for learning process
RT10	It is a good idea because we can constantly keep track of how learning is taking place. Whether the learners have learned or not. It can also help us to improve our own practices because it makes us aware of which methods are successful.
RT11	My thoughts toward the use of formative assessment is to prepare a quality task to learners, gives a feedback on time and give learners chance to do a self-assessment
RT12	It is good for each teacher because it is during formative assessment that the teacher will able to improve teaching and help learners know where they need to make changes
RT13	It was educative as I have learned that when we are teaching we should not wait until we are done with our topic but we can assess our learners during the lesson.

	Ask questions to the learners and test their understanding
RT14	It is an effective form of assessing learners because it allows the teacher to know if learning has taken place in class that time and allows the teacher to quickly change his/her approach of teaching a particular topic or concept if he/she found that it is not effective enough
RT15	I thought it was meant for promotional purpose only
RT16	Its also a good tool of determining if learners have master what they have learned
RT17	Formative assessment is the way out for learners to understand what the learners have been doing or have been taught and should be encouraged in all lesson plans
RT18	I feel they should be done throughout the lesson through questioning, feedback and mind mapping concept emerging from the topic
RT19	Formative assessment is crucial because it help teachers to measure students' understanding hand on instead of waiting
RT20	Formative assessment should be necessitated as it acts as an informative mechanism. What the learners have achieved well and what they need to improve.
RT21	It will help the learners to master the content very well which will be useful in their formal assessment (examination)

Code	Responses to question 5 [to answer question 3] [disposition] [A graph was drawn under quantitative data] Has participation in this workshop changed your attitude towards practical activities or not? If so, in which ways? Please explain.
RT1	Yes it changed my attitude towards practical activities in the way that I have to take practical activities seriously because it makes the classroom live, learners engaged well in the lessons and practical make it perfect. Learners learn well by doing.
RT2	Yes it make me realize how practical activities helps learning and retention of information to the learners. It will help learners to master and link concepts and develop them too.
RT3	Yes, I got to learn that as a teacher I have to involve learners in practical activity. I learn that practical activities is important and it can help learners to have a broad understanding of new concepts
RT4	Yes, now I can able to prepare practical activities even if the school does not have a science lab or the lab is not equipped
RT5	To a certain extent yes some of the practical I have done them during my teaching, but not as nicely as it was done during the week. The part of assessment was so fascinating.
RT6	I am more encouraged to engage in practical activities. I also realized that the aspect of TIME does not really have to be a factor. Because in fact the learning you are trying/rushing to teach via theory is actually taking place during practical activity
RT7	Yes because I got different views from different people
RT8	Yes it does, I normally had problems of doing practical activities in Physical Science with the learners, because I had no idea of where to get the resources. For example I have learnt how to prepare CO_2 and hydrogen gas
RT9	Yes, it is because all along I use to think that practical activities can be only done in the lab, (fully equipped one). But now I developed an attitude that I can use available resources in the environment and do practical activities
RT10	No. I always believed that practical work is an important task of science learning. It was just a confirmation of my idea
RT11	Exactly. I was impressed by lots of practical activities done during the lesson

RT12	It has changed. I am that teacher that does not believe in practical activities, with the experience that learners do not learn anything. Now I am rethinking my teaching approach. I think I have to change my teaching strategy of conducting practical activities.
RT13	Yes because we use to give excuses that there are no equipment at school but now I have an idea that you can get them in shops at a cheaper price or use local materials
RT14	Exactly. It changed my attitude towards teaching learners. I wish my class can be as participatory as the one we hand throughout the week.
RT15	Yes the worksheet has encouraged me to use more practical activities in my teaching
RT16	Yes, using easily accessible resources makes the lesson interesting
RT17	Yes it changed me in the sense that practical activities enhance learning and understanding.
RT18	Very much, though not a science teacher but I really want to encourage teachers to do it in other subject too
RT19	Yes I started to have a good feel about science even though I do not teach it in school. Participants were open and were able to share their experiences.
RT20	Yes. It has given me an impression that we cannot have assertion of something before carrying out an experiment to test before assertion
RT21	Yes it really changed. Through sharing of ideas from colleagues

Code	Responses to question 6 [to answer question 4] Would you recommend the activities and workshops carried out this week to be conducted to other science teachers in Namibia?
RT1	Yes I recommend to be given. Because most teachers do not conduct practical simply because they do not have laboratory and apparatus. By looking at what was used is just the accessible resources.
RT2	I highly recommend that these activities should be carried out with other science teachers to that it helps them realize the importance of practical activities to both learners and teachers
RT3	Yes. Most teachers in Namibia are interested in carrying out practical activity but they are not access to equipped science labs
RT4	All activities were educative and suit in our Namibian curriculum. Most of us (teachers) do not conduct practical activities due to the fact that schools are not equipped with resources but we don't want to improvise
RT5	Very much recommending for that to happen. Many teachers find it difficult to teach from context to contents. I am even planning to do this to my teachers in my circuit.
RT6	Oh yes, out including me are reluctant to carry out practical activities due to various reasons such as –Time- it is time consuming and the syllabus does not allocate time for that. -Some believe that they can only do practicals in labs -Some have no resources And moreover, we have less knowledge on how to access resources within our reach
RT7	Yes please. It will lead to discovery learning. Learners will discover lots of scientific concepts
RT8	Yes I strongly recommend it in a sense that it can help the learners to get the test of science, and help them to learn science. Also, it is important because carrying out such activities and workshops can help impose teachers' practice.
RT9	Yes other teachers should be trained so that they can develop the same attitude as me
RT10	Yes because teachers are unaware of those simple experiments we can carry out. Most teachers are worried about spending their money on things which are bought.

RT11	Yes all the science teachers needs to conduct the practical activities because science is more about practice that allows learners to observe using their sense organs
RT12	Yes this gives an opportunity to the teacher to use the available materials in their environments. Sometimes the teacher might not do the practical activities because there are no materials
RT13	Yes because they were educative practical activities help our learners to understand better
RT14	Yes because they help with the visualization of science other than just explaining without using experiments
RT15	Yes because they are contextualized
RT16	Yes its interesting to the learners, learners tend to define science they use them everyday life
RT17	Yes because it through practical activities will learners be able mastered what they have learned
RT18	The Oshikundu activity I think it is fun and indigenous
RT19	Yes because that is one way to make science interesting by doing so we can be able to bring the reality into the classroom
RT20	Yes more them from the way of being content-dependent only while there can be content dependent (local material) that can help learners of different learning needs to learn better
RT21	Yes, because it is useful to the learners and will create more rooms for learners to explore their environment

Code	Responses to question 7 Any other comments
RT1	Teacher should change their attitude on practical activity and do them with their learners as they make learners understand
RT2	Teachers should be helped to change their attitudes towards practical activities and not giving excuses of unavailability of resources and time constraints
RT3	The activities were interesting. I like the materials used and the way the presenters explained/told us where they bought the materials
RT4	More time needed to revise some of the practical activities
RT5	Thank you for the opportunity offered
RT6	No comments
RT7	Well done Eva, Dr Ken and Felisia for a wonderful activity. I learned a lot from you. Keep it up
RT8	No comments
RT9	I would like to emphasize that teachers need to change their attitude towards practical activities and assessment. This is important as it ensure effective learning
RT10	I like the demonstrations
RT11	Science lessons need enough time which allows students to do their practical activities
RT12	It was an interesting week and I have learned a lot which I will definitely do it with my learners
RT13	No comments
RT14	Just bring up more practical activities during the next session for us to gain skills and apply them in schools
RT15	No comments
RT16	No comments
RT17	Eva and your team you assets in my Bed Hons
RT18	No comments

RT19	Eva is a wonderful presenter and I have learned a lot from her. She is innovative and full of energy
RT20	Yes, thanks for entitling us to instilling a positive attitude towards the use of practical activities using easily accessible resources
RT21	No comments

Appendix F1: Permission letters to the Regional Directors

RHODES UNIVERSITY

EDUCATION DEPARTMENT

Tel: +27 (0) 46 603 8383

Fax: +27 (0) 46 622 8028

The Director of Education
[redacted]
P O Bag 2028
Ondangwa

Dear Mr Kafidi,

Subject: Request for permission and access to conduct educational research at [redacted] CS in Onathinge Circuit, Oshikoto region

I am Eva Ndagwedha Asheela, a part-time registered Master in Education (Science Education) student at Rhodes University (student number: 13a7193), and a Chief Education Officer for Natural Sciences and Mathematics sub-division at NIED, specifically responsible for the subject Physical Science grades 8-12. I hereby humbly request for permission to conduct a research study at [redacted] for one week in June/July 2016.

My topic of study is: ***An intervention on how using easily accessible resources to carry out practical activities in science influences science teachers' conceptual development and dispositions towards practical activities in science.***

Research has shown that practical activities are one of the challenges facing science teachers for various reasons such as the lack/shortage of science apparatus, equipment and chemicals in schools and the lack of knowledge/exposure about the use of alternative resources which are readily available in our local environment to carry out practical activities. For this reason, this research study, which is comprised of **three phases**, will help in exposing teachers to the use of easily accessible resources which can be used in the science classrooms. The **first** and **second phases**, which involved carrying out workshops with participants, have already been completed during the Rhodes University contact sessions at NIED. The **third phase** is intended to observe how the participant is implementing the activities which were carried out during the workshops. One of my participants is a Physical Science teacher at [redacted] in Onathinge circuit, Oshikoto region.

I would like to assure your office that, should I be granted permission, the research ethics will be applied at all times when carrying out my research. The identity of each participant and their views or contributions, the school, will be treated with a high degree of confidentiality and anonymity.

Your humble understanding in this regard will be highly appreciated and I look forward to hearing from you through completion of the template at the bottom of this page.

Sincerely,

Eva Asheela
Rhodes University
MEd in Science Education Student

I hereby grant permission to the researcher.

Name……………………………… Signature………………………Date………………………..

RHODES UNIVERSITY

Grahamstown • 6140 • South Africa

EDUCATION DEPARTMENT

Tel: +27 (0) 46 603 8383

Fax: +27 (0) 46 622 8028

The Director of Education

Otjozondjupa Education Directorate

01 June 2016

[redacted]

Subject: Request for permission and access to conduct educational research at [redacted] in Okahandja Circuit, Otjozondjupa region

I am Eva Ndagwedha Asheela, a part-time registered Master in Education (Science Education) student at Rhodes University (student number: 13a7193), and a Chief Education Officer for Natural Sciences and Mathematics sub-division at NIED, specifically responsible for the subject Physical Science grades 8-12. I hereby humbly request for permission to conduct a research study at [redacted] for one week in June/July 2016.

My topic of study is: ***An intervention on how using easily accessible resources to carry out practical activities in science influences science teachers' conceptual development and dispositions towards practical activities in science.***

Research has shown that practical activities are one of the challenges facing science teachers for various reasons such as the lack/shortage of science apparatus, equipment and chemicals in schools and the lack of knowledge/exposure about the use of alternative resources which are readily available in our local environment to carry out practical activities. For this reason, this research study, which is comprised of **three phases**, will help in exposing teachers to the use of easily accessible resources which can be used in the science classrooms. The **first** and **second phases**, which involved carrying out workshops with participants, have already been completed during the Rhodes University contact sessions at NIED. The **third phase** is intended to observe how the participant is implementing the activities which were carried out during the workshops. One of my participants is a Physical Science teacher at **JG van der Walt SS in Okahandja Circuit, Otjozondjupa region**.

I would like to assure your office that, should I be granted permission, the research ethics will be applied at all times when carrying out my research. The identity of each participant and their views or contributions, the school, will be treated with a high degree of confidentiality and anonymity.

Your humble understanding in this regard will be highly appreciated and I look forward to hearing from you through completion of the template at the bottom of this page.

Sincerely,

Eva Asheela

Rhodes University

MEd in Science Education Student

I hereby grant permission to the researcher.

Name……………………………… Signature………………………Date………………………..

Appendix F2: Permissio

RHODES UNIVERSITY

Grahamstown • 6140 • South Africa

EDUCATION DEPARTMENT

Tel: +27 (0) 46 603 8383

Fax: +27 (0) 46 622 8028

The School Principal

[redacted]

Okahandja Circuit

Otjozondjupa Region

Dear Mr Williams

Subject: Request for permission and access to conduct educational research at

[redacted]

I am Eva Ndagwedha Asheela, a part-time registered Master in Education (Science Education) student at Rhodes University (student number: 13a7193), and a Chief Education Officer for Natural Sciences and Mathematics sub-division at NIED, specifically responsible for the subject Physical Science grades 8-12. I hereby humbly request for permission to conduct a research study at [redacted] for one week in June/July 2016.

My topic of study is: ***An intervention on how using easily accessible resources to carry out practical activities in science influences science teachers' conceptual development and dispositions towards practical activities in science.***

Research has shown that practical activities are one of the challenges facing science teachers for various reasons such as the lack/shortage of science apparatus, equipment and chemicals in schools and the lack of knowledge/exposure about the use of alternative resources which are readily available in our local environment to carry out practical activities. For this reason, this research study, which is comprised of **three phases**, will help in exposing teachers to the use of easily accessible resources which can be used in the science classrooms. The **first** and **second phases**, which involved carrying out workshops with participants, have already been completed during the Rhodes University contact sessions at NIED. The **third phase** is intended to observe how the participant is implementing the activities which were carried out during the workshops. One of my participants is a Physical Science teacher at [redacted].

I would like to assure your office that, should I be granted permission, the research ethics will be applied at all times when carrying out my research. The identity of each participant and their views or contributions, the school, will be treated with a high degree of confidentiality and anonymity.

Your humble understanding in this regard will be highly appreciated and I look forward to hearing from you through completion of the template at the bottom of this page.

Sincerely,

Eva Asheela

Rhodes University

MEd in Science Education Student

I hereby grant permission to the researcher.

Name……………………………… Signature………………………Date…………………………..

RHODES UNIVERSITY
Grahamstown • 6140 • South Africa

EDUCATION DEPARTMENT
Tel: +27 (0) 46 603 8383
Fax: +27 (0) 46 622 8028

The School Principal

[redacted]

Onathinge Circuit

Oshikoto Region

Dear Ms Hamunyela

Subject: Request for permission and access to conduct educational research at

[redacted]

I am Eva Ndagwedha Asheela, a part-time registered Master in Education (Science Education) student at Rhodes University (student number: 13a7193), and a Chief Education Officer for Natural Sciences and Mathematics sub-division at NIED, specifically responsible for the subject Physical Science grades 8-12. I hereby humbly request for permission to conduct a research study at [redacted] for one week in June 2016.

My topic of study is: ***An intervention on how using easily accessible resources to carry out practical activities in science influences science teachers' conceptual development and dispositions towards practical activities in science.***

Research has shown that practical activities are one of the challenges facing science teachers for various reasons such as the lack/shortage of science apparatus, equipment and chemicals in schools and the lack of knowledge/exposure about the use of alternative resources which are readily available in our local environment to carry out practical activities. For this reason, this research study, which is comprised of **three phases**, will help in exposing teachers to the use of easily accessible resources which can be used in the science classrooms. The **first** and **second phases**, which involved carrying out workshops with participants, have already been completed during the Rhodes University contact sessions at NIED. The **third phase** is intended to observe how the participant is implementing the activities which were carried out during the workshops. One of my participants is a Physical Science teacher at [redacted].

I would like to assure your office that, should I be granted permission, the research ethics will be applied at all times when carrying out my research. The identity of each participant and their views or contributions, the school, will be treated with a high degree of confidentiality and anonymity.

Your humble understanding in this regard will be highly appreciated and I am looking forward to hearing from you through completion of the template at the bottom of this page.

Sincerely,

Eva Asheela

Rhodes University

MEd in Science Education Student

I hereby grant permission to the researcher.

Name……………………………… Signature………………………Date………………………….

Appendix F3: Permission letters to the teachers

RHODES UNIVERSITY
Grahamstown • 6140 • South Africa

EDUCATION DEPARTMENT

Tel: +27 (0) 46 603 8383

Fax: +27 (0) 46 622 8028

PO Box 94, Grahamstown, 6140

01 June 2016

Dear Research Participant

Re: Participation in research on the use of easily accessible resources in the science classroom

Thank you for agreeing to be a research participant in my study. As per our discussion, my research area is 'How exposure to the use of easily accessible resources in the topic on formation of carbon dioxide influences Physical Science teachers' dispositions towards science'.

The study will be conducted in **three** phases. The first phase requires participants to complete a questionnaire. The **second phase** of the study involves an intervention in the form of a workshop on training participants on the use of easily accessible resources in science classrooms. After the intervention, **the third phase** of the study requires volunteers for further research on implementation on the use of easily accessible resources in their classrooms.

Your participation in this research study is completely voluntary and you can withdraw at any time. The data collected in this study will be published as a Rhodes University half thesis. The identity of each participant and their views or contributions will be treated with a high degree of confidentiality and anonymity.

Sincerely

Eva Asheela

Rhodes University

MEd in Science Education Student

I agree to participate in the research on condition that I can withdraw at any time.

Name…………………………………………………………………………….

Signature…………………………………………………………………………..

Contact number…………………………………………………………………

RHODES UNIVERSITY
Grahamstown • 6140 • South Africa

EDUCATION DEPARTMENT

Tel: +27 (0) 46 603 8383

Fax: +27 (0) 46 622 8028

PO Box 94, Grahamstown, 6140

01 June 2016

[redacted]

Subject: Participation in educational research on the use of easily accessible resources in the science classroom

Thank you for agreeing to be a research participant in my study. As per our discussion, my research area is '***An intervention on how using easily accessible resources to carry out practical activities in science influences science teachers' conceptual development and dispositions towards practical activities in science.***

As indicated that this research is divided into **three phases** of which **phases one** and **two** are already completed successfully when you participated in workshops on the use of easily accessible resources to carry out practical activities at NIED. The **third phase** of the study requires volunteers for further research on implementation on the use of easily accessible resources in their classrooms. Thanks once again for volunteering to participate in the third phase.

Your participation in this research study is completely voluntary and you can withdraw at any time. The data collected in this study will be published as a Rhodes University half thesis. Your identity and views or contributions will be treated with a high degree of confidentiality and anonymity.

Sincerely

Eva Asheela

Rhodes University

MEd in Science Education Student

I agree to participate in the research on condition that I can withdraw at any time.

Name…………………………………… Signature…………………… Date…………

Appendix G1: Lesson observation transcript teacher Madam Physics (TMPO)

Practical activity 1: Preparation of carbon dioxide using egg shells and hydrochloric acid

T: asking learnershow long the egg shells took to dissolve in vinegar, related it to hydrochloric acid whether it will take the same time as vinegar to dissolve the egg shells.

LLL: No Ms

L: hydrochloric acid is stronger than vinegar

T: [Took a container (plastic bottle) and put egg shells, then hydrochloric acid]

L: Ms be careful with the acid. Some acids are very reactive. (learner telling the teacher when she was putting hydrochloric acid in a container with egg shells).

LLL: excited to see the balloon very big and inflated

Practical activity 2: Preparation of carbon dioxide using vinegar and baking soda

T: [holding baking soda and vinegar and asking learners to identify the substances]. Where have you see this one?

LLL: In the shops,….. at the supermarket,…. at home,…. in the kitchen….

T: [while holding the baking soda], what type of substance is this? What do you think we happen when we react this baking soda with vinegar?

LLL: it contains carbon dioxide

T:[mixing the baking soda and vinegar and telling learners] now the bicarbonate of soda will mix with vinegar, let us observe.

LLL: bursting into excitement, very pleased that the balloon is expanding.

Practical activity 3: Testing carbon dioxide from exhaled air

T: You are not plants right. Which gas do you breathe in and which gas do you breathe out?

LLL: we breathe in oxygen, we breathe out carbon dioxide

T: Can you taste for carbon dioxide gas?

LLL: Yes we can… We can use limewater.

T: So the clear limewater can also test the carbon dioxide from your exhaled air?

T: Okay let us see….I will put limewater in this test tube but I will not use my own carbon dioxide I will give you.

T: who wants their carbon dioxide to be tested?

LLL: Learners volunteer, 3 learners volunteer

T: [gave drinking straws to the learners]

T: [took a bottle of limewater and asked learners to confirm if the limewater looks clear]

LLL: confirmed that the limewater looks clear

T: [puts limewater in three different test tubes and gave learners to bubble exhaled air through the clear limewater.

LLL: [each of the three learners bubbled their exhaled air through the clear limewater]. One girl appears to be showing off through body language and showing excitement that she is given the opportunity to bubble her own exhaled air through the carbon dioxide.

T: [telling the learners to blow the exhaled air in the test tube softly]

L: [a girl blowing exhaled air through clear limewater in the test tube]

T: Put the straw inside the limewater itself [telling the learner]

T: [telling another leaner, a boy to keep on blowing into the limewater]

L: what colour is that?

T: [holding the three test tubes with limewater that has turned milky and asking learners what they are concluding]

LLL: There is carbon dioxide in exhaled air

T: So next time you tell people that there is carbon dioxide in your exhaled air, at least you have tested it.

Practical activity 4: Testing carbon dioxide from a coca-cola cool drink

T: [opened a cool drink bottle and explained to the learners that she will put a balloon at the mouth of the bottle and give the bottle a little shake in order to capture the gas into the balloon]

T: [shaking the bottle with a balloon on the mouth]

T: [explaining to the learners that they have already tested the carbon dioxide from exhaled air, they are now going to test the gas released from coca-cola cool drink, from the reaction of vinegar and baking soda and from the reaction of hydrochloric acid and egg shells

T: [gave a test tube with clear limewater to one learner to test for the gas released from the reaction of baking soda and vinegar, putting the balloon on the mouth of the test tube]

L: holding the test tube and moving around to show the other learners in class

L: [another learner was given a test tube with clear limewater in order to be able to test the gas released from the coca-cola cool drink. Two learners and the teacher helping one another to put the balloon

LL: [learners moving around holding the test tubes with balloons on them, testing for the gases in different ways and then determining the results]

LLL: the learners are so excited and surprised to see the results.

T: [explaining that the traditionally brewed fermented beverage *Ontaku/Oshikundu* is taking long to ferment]. We will put it in hot water. What will the hot water do?

L: It will make the reaction go faster

Practical activity 5: Reaction between aluminium foil and caustic soda

T: telling the learners that in this lesson, we are going to use aluminium foil and caustic soda. What is aluminium foil? Where do we get it?

LLL: all speaking at once…

T: It is as if you people are singing ne? What is Aluminium?

T: One person, put your hand up.

L: it is a metal

T: Okay, it is a metal. We are going to react it with caustic soda, which is sodium hydroxide. What type of substance is sodium hydroxide

L: it is a base

T: okay, let's see.

T: asking what caustic soda is used for?

L: for cleaning…

T: yes, for cleaning what?

L: scales…,

T: yes, scales….

L: blocked drains

L: yes Mrs what about battery acid

T: Okay I'm very happy to hear about battery acid, we will talk about it

T: [preparing sodium hydroxide solution by reacting caustic soda with aluminium foil]

T: After the balloon got inflated with gas, she took a burning splint to bring in contact with the balloon

LLL: woooh, that's a bomb. Some learners looking scared

T: asked learners to predict the gas produced

LLL: hydrogen

Practical activity : Concentrated sulfuric acid (98%) and white sugar

T: Explaining that the class is going to do a practical activity outside, using concentrated sulfuric acid and white sugar. She explained that there is a need to do the practical activity outside and that they needed to observe what was happening.

LLL: sulfuric acid is battery acid… It will go "boom"

LLL: shouting and screaming, it looks like a bomb, this is a nuclear bomb, as they observe the effect of sulfuric acid on white sugar.

T: what happened to the white sugar?

L: it is like a volcano that erupted and solidified…

L: Miss the smell that came out was almost like for a tamalaitjie [a tamalaitjie is an Afrikaans word for a fudge like sweet which is home made by heating white sugar until it turns brownish, which can be done when white sugar is mixed with fresh milk, condensed milk, etc. It gives of as similar smell as the smell which learners experienced in this practical activity]

LLL: The whole class broke into laughter and saying yes it is true as their fellow learner described the smell.

L: There was smoke coming out from the sugar as it was burning….

T: There was smoke, meaning that there was a gas produced or?

Appendix G2: Lesson observation transcript teacher Mrs Confidence (TCO)

Practical activities 1: Acids and bases

TCO: Takes various liquids that were brought by the learners and them informs learners that she also has some liquids from the laboratory. She takes hydrochloric acid and shows to the learners. She indicated to the learners that the hydrochloric acid is the diluted one not the concentrated one. She further showed vinegar, soap water, caustic soda (sodium hydroxide). She explained that the caustic soda is added to water to dissolve it in order to form a solution (showing the caustic soda to all the learners while holding it in her hands). She also showed the 100% lemon juice, bleach (JIK), she asked if learners know JIK which is used for white shirts to become whiter. She also showed learners Domestos and explained that it is also used for cleaning.

She showed the learners universal indicator and learners had never seen the universal indicator before. She says, and the main thing is also the universal indicator.

T: explains that universal indicator solution will be added to each of the liquids.

LLL: learners hold containers of different liquids which they brought from home and the teacher added universal indicator solution to each one of these liquids.

TCO: Okay we put the universal indicator (saying while putting drops of universal indicator in a container of one of the learners).

T: Shake a bit (telling the learner to shake the container after having put drops of universal indicator solution in the container).

T: Okay, move it up so that they can see (referring to the learners). Can you see the colour? Asking the learners

LLL: Yeeees

T: yeeee?

LLL: Yes

T: Then we will take the next one, (teacher taking the next container of the next learner to add drops of universal indicator solution).

T: What is that? Read it?

L: salt water (a learner responds)

T: Salt water, then we put, (while putting universal indicator solution)

T: Shake a bit (telling the learner)

LLL: Turned into laughter and excitement upon seeing a colour which is different from the colour of the colour in the first container

T: Can you see the colour?

LLL: Yes Ms

T: Okay we have….aaa… this, what is that one?

L: Soap water

T: Adding drops of universal indicator solution

T: Check the colour for the soap water….

L: Ooohooo, blue…

T: Somebody else to come and help, ladies? Ladies? To make gender balance.

T: What is that?

L: vinegar

T: adding drops of universal indicator

L: wuuuuh…. (and broke into laughter)

T: Show them…., show the group, ahaaa,

LLL: some learners uttering, strong acid…

T: what is that>

L: hydrochloric acid

T: (adding drops of universal indicator solution), look at this,

LLL: it is a strong acid

LLL: surprised as the colour of the hydrochloric acid is the same as the colour of the vinegar

T: What is that?

L: sodium hydroxide

LLL: aaaaau, yeeee, …. (Learners look excited because of the different colours)

L: strong…

L: strong what? (another learner asks)

L: hey hey, strong what? Another learner asks

L: strong alkali (a learner responded)

T: Domestos, adding drops of universal indicator solution. (stirring using the dropper pipette because the domestos is thick and explaining that because I have used this one to stir in the domestos, I cannot use it anymore in the universal indicator, I have to use the new one).

T: I put it there then I use the other pipette

L: this is JIK

T: putting drops of universal indicator solution in the JIK

T: okay that is a?

L: lemon Juice

L: lemon what?

L: lemon juice

L: strong acid (the colour of lemon juice is red just like the colour for vinegar and hydrochloric acid)

T: now you have seen how we have used those liquids that we have prepared for you.

T: there is a reason why I did not want to use the pipette that I have used to stir the domestos back in the universal indicator solution. I want you to check this one.

T: we said this is what? (holding a bottle)

L: sodium hydroxide

T: sodium hydroxide ne, soo, let us put this sodium hydroxide in this ka container.. just a little bit (putting the sodium hydroxide in the improvised beaker). Then we take the universal indicator, and put it in there, you see the colour? Okay now, I'm going to take the vinegar. Okay what was in here first?

LLL: sodium hydroxide

T: Okay, sodium hydroxide, then we add the indicator, now we are going to put the vinegar. Okay, you see the colour,

LLL: Yes…

T: Okay, we put in the vinegar (adding vinegar little by little) until a colour change occurs

LLL: waaaaa, breaking into laughter and looking amazed by the colour change

T: which means when you are using these chemicals you must use clean containers because if you use a container where there was another chemical, it will affect the other one.

T: Let me add sodium hydroxide… Can you see the colour? What is the colour now? What is that colour?

LLL: Green, green, green….

T: First there was sodium hydroxide, we add vinegar, until the colour changed to green, which one has this colour? Check in your book the green colour…

LLL: neutral… neutral… neutral…

T: and which pH value

LLL: seven…

T: Which means, if you are having a base, which is sodium hydroxide, and vinegar, which is a what?

LLL: Acid…

T: they will form what?

LLL: a neutral…

T: yes they'll form a neutral solution, are we together ne?

LLL: Yes,

T: That is done.

T: okay, your liquids, anybody to help out, you read out what is there…

T: The teacher kept adding and adding drops of universal indicator to different containers of liquids which were brought by the children.

Practical activities 3: effect of different liquids on white sugar

T: putting white sugar in a beaker, okay, so we add water, a little bit of water, to the sugar, aaaand, yes, sugar,

T: And we take the strong one, okay now we take the sulfuric acid and put it in the mixture

LLL: Oh, osuuka yapi nale (so the sugar has burned already), oh, oh, oh, shuuuu,

LLL: oh, ohoooo, breaking into laughter when they saw how sulfuric acid dehydrated the sugar

L: oh, ano shi sha tulwamo shahugunina oshike [what was put in las], asking what was put in the sugar to make it burn

T: Sulfuric acid

T: That experiment that we have done outside there on… what was that

L: sulfuric acid

T: sulfuric acid only? We do what?

L : We added water and sugar…

T: who can explain to me the process that was done there, who have seen it from the beginning to the end? One person, stand up?

L: we take a container and then we put sugar… we put a little bit of water… we put sulfuric acid…and the sugar starts burning…

T: Ookay, first we took the container, we put in the sugar, then we put in the water, when we put the water in that sugar, have you seen what happen?

T: okay after that, we put the sulfuric acid, we saw what happened?

LLL: yees,

T: okay we are still continuing with our experiment in the sugar, we take sugar, we take hydrochloric acid and then we have vinegar. We are going to put these liquids into this sugar

L: Sorry miss I want to go far

T: Okay, we put in the hydrochloric acid. It is not diluted. Okay, then, we take the vinegar, and put it in the sugar again. That is done! What happened? Okay.

T: Giving a group activity: after you have observed what happened when we put hydrochloric acid, water, vinegar and sulfuric acid in the sugar, write down what you have observed about the effect of these different liquids on sugar. Do it quickly in your groups.

Appendix H1: Semi-structured questions for interview

Stimulated recall interview questions after implementation

1. What are your experiences in implementing these activities in your science classroom? What did you enjoy the most and why?
2. What are the challenges which you experienced during the implementation

Appendix H2: Interview transcript teacher Madam Physics (ITMP)

What enabled her, what she enjoyed most during the lesson?

Me: Maybe I would like to find out in this regard, how did you find this experience of actually implementing, from the workshop participation to implementation with your learners?

ITMP: Oh, my dear! This one, I never had a lesson and I came out very tired like the one I implemented the activities in the class because I could say maybe learners are excited, I don't know as if I don't do practical activities before, learners were very much interested in that thing. You know I teach in a multicultural school, I have different cultures and I even brought in Oshikundu, you know Oshikundu is just coming from a certain culture it is not for everybody, not all of them knows it. It was a challenge for them, yet they were enjoying it. The fact that it produces a gas. The fact that it is supposed to be a home something, something to be cooked at home and the teacher just brought it to the class. How learners were enjoying that thing, it was a very interesting lesson, it was, myself I was as if I teach new learners, not the same learners that I usually teach because learners are asking questions, learners want to do things, even if they don't know how to do them like Oshikundu, it was a good experience.

You know these activities have something in common even if it is not from your culture. To make them understand you still need to bring them to the concept of fermentation. The science concept itself. The moment you mention that, even those that are not coming from that culture will now understand it much better or easily. Because I remember that at the beginning before I talked about anything else I asked them what is this? Some of them are saying Oshikundu..

ITMP3: Yes and I remember someone mentioning *mageu*, and myself I have seen that *mageu* but I don't know how I can relate it to Oshikundu. Someone is saying it is both Oshikundu but one , because it was not that one was ready, ready in a way that it has fermented, the other one is not, but then it was not diluted, let me put it that way. The thick one now they are saying it is Oshikundu for eating while the other one is Oshikundu for drinking, you know. They have the picture because I also have coloured learners, some are white, some they do not know what it is they are quiet but when we just brought up the concept of fermentation, they came to understand. That okay, because the questions were now going on that Oshikundu is made up of Sorghum, Mahangu, they know what is sorghum, they know what is Mahangu. Now looking at these, and they they put sugar and water and they link it now to that fermentation that they were talking about.

Me: And some maybe may relate to mageu from their culture.

T3: They relate them, they might think maybe it is almost the same as what they do in their culture.

The challenges she encountered

Me: But maybe I should ask, what made you to do this activity in the afternoon and not in the normal lesson?

ITMP: The think is okay I am a bit behind with my syllabus and I just thought of maybe let me just have my normal classes during the day and I can have it in the afternoon. Another reason is I thought it will take me a bit longer than the normal lesson duration, which is true, it took me so much longer and I did not want to do it myself quickly and I finish because of the time. I wanted to get learners involved also because if it is during the normal classes, I might cut them in doing, because you know when learners are involved in doing, they are sometimes a bit slow and I have to be patient and soon the bell just ring and they are not done.

Me: In the 40 minutes period.

ITMP: But then I thought in the afternoon I will have enough time that is why I told the learners it is fine you can go home, I want to start at two O'clock and I want to have you even up to four. So they came prepared so that I can have enough time to involve them as well. Because I wanted them to do some of the activities themselves to see.

Me: Themselves, oo I see. So from here I can tell that some practical activities take long…

ITMP: Yes they take long especially when you want learners to understand because in the normal class, you will likely do everything yourself and just do things quickly and then you are done.

Me: So you said the learners were excited during these activities and then maybe lastly on this implementation part, maybe I just want to find out is there any challenges maybe, anything that was difficult for you maybe when you were implementing?

TMP: Mmmm, not really but like I said, it is as if it is not the learners that I normally teach. They were very excited, so I managed the class but how do I put this now, the happiness that was in the class, you know when the people are happy, too much happy, it might also bring you a bit of noise in the class because everybody wants to comment, everybody wants to ask, it was just a bit on the side of classroom management, plus an activity that I remember we did the reaction of sugar and sulfuric acid, it was challenging me because I thought maybe the learners might overreact over it, I was a bit scared about doing it but it was okay I've asked the learners to go outside with me, I was now thinking about the smell that it makes, it was a big challenge, but at least the learners listened, they did not really inhale that gas. I was also a bit scared about handling the sulfuric acid itself because it is very concentrated but it did not, it was not a problem, it was just a challenge but it went well.

Me: Okay. No, that is basically it I wanted to find out from yo. Because actually I attended the workshop, I attended the implementation but I just wanted to, these questions were mainly aimed at finding out more details about what has happed

Appendix H3: Interview transcript teacher Mrs Confidence (ITC)

What enabled her, what she enjoyed most during the lesson?

Me: Maybe first of all I should ask, what did you enjoy most about these practical activities?

TC: Iyaa, okay what I have enjoyed the most is when I was looking at the activities that we have been carrying out. The first one is the objects or the materials that were brought by the learners. Which means that in our environment there are materials which can be used in the classroom which means we don't have only to focus more on things that can be found or can be bought in the lab. So using those materials, it was so enjoyable and you can see the effects and the learners can able to make the observations themselves so it was enjoyable.

Me: okay so that part of bringing things from home? So did this motivate you in a way, to do practical activities?

TC: Iyaa, it does because by looking at how we have carried out the experiments, you can really see that the learners are enjoying what they are doing. Because when I went to one class now they were asking me now because of those eggs that we have done with them yesterday, they are asking Ms, where are the eggs, we want to go back there. Then I said aaye you have to go there later, which means they are interested to see what is happening.

Me: I would also like to find out from your side that when you were conducting these practical activities, what are some of the problems or some of the challenges or some of the things which are kind of hindering you from effectively carrying out the activities?

The challenges she encountered

TC: Iyaa the first one is the room. Because for now, we are just using this classroom but come next year, this classroom will be occupied by the grade 12s. Which means that we will not have any place where we can carry out our activities. As you know that these activities, they need a place for preparation, you need to prepare them somewhere. But now if we don't have that room so that we can come and prepare. That means… and to keep also, to keep them, it is a challenge. Because those learners, they have to check even the next day, that is why even when I did this part of, the beginning of this topic, when we were using the litmus paper, after I am done, we have to throw away those liquids because we have nowhere to keep them. Iyaaa.

And the other thing, maybe the time, the time also. Because in order to do these things you need to prepare them, and looking at our subjects that we are teaching, the subject allocation, sometimes that day is full, you won't even have time to go and do the preparation. Iyaa, so, now sometimes you have to… Like now sometimes I have to go up to five O'clock in order to do something for tomorrow.

Me: Hmm, having talked about the classroom, because you said that this classroom was build because of the extension of the curriculum of the school, I remember you explained to me the first day said this classroom will be used by the grade 12 but for now we can use it. So, can you describe for me briefly, what is the challenge in carrying out the practical activities in the classroom where the learners are based?

TC: Okay, Firstly, carrying the materials to the classroom is a challenge. Because you might take them there, or you need, you have more activities, I mean you have more materials. If you take them there, learners are learners, you will find that they have played with it. So when you take them there, by the time you come back and take their… for example you have those 3 buckets, you cannot carry them at the same time, you have to take some, or…

and again .if you look at our classes, they are also full, even the area where you have to carry out the experiments, like this one that we have done now, you can see that, that table there, it makes it easy for all learners to come and move around and check what is happening. Now looking at the classrooms, even just the place where you have to carry out those ones, that is why when you check those classrooms they don't even have the table for the teacher, where the teacher have to put his or her books. You have to use learners tables

TC: Ja, I really enjoyed doing those experiments because for me, I think not only the learners that have learned but even myself because I have never done those activities, neither with our school or when I become the teacher like having the universal indicator for the learners to do the colours. It was also an experience for me to see those things, the colours… And the other thing is what I have learned, I have learned that this topic, the way I used to teach it, it means that next year, I won't teach it as I am teaching now…. Because I have seen that these three topics, they have to go hand in hand. I don't have to finish this one then start over with the other one which means that when I carry them all at the same time, acids and alkali, then from there, because I have already talked about acids and alkali, then I will just conclude with the neutralisation. Which makes it easy, because the grade 10 they were lucky I was not done with it before you came, so when we discussed during the lesson, I see that it went well.. it has worked.

Me: Okay now, thinking about the future, how possible, the possibility of getting materials in future? Then some of the materials, from the beginning you said you enjoyed when these learners bring some of the materials, but of course they can't bring all the materials, so like some of the materials that needs to be bought from the shops, or or… what do you think about the school's position in terms of helping out… something in that line.

TC: For now, before we were having this school fund, so we might come and get the challenge of not having enough money to buy the staff. Now that we are having this UPE, because comparing with what we normally get from the SDF, we could not accommodate to buy those things. But looking at the amount that we have received, I think we can go back to buy those things for the materials.

TC: Like that topic for exothermic, we have washing powder, so to have that one is not difficult is only that improvising, just to do that activity, we don't have that knowledge.