Exploring how Grade 9 Physical Science teachers mediate learning of the topic of chemical changes

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By

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DECLARATION OF ORIGINALITY

I, Orrice M Likando, hereby declare that this research is my original work and has not been previously submitted to any other university for a degree. Where people's work has been used, it has been duly acknowledged in the text.

Signature **Date: 5 April 2021**

DEDICATION

This thesis is dedicated to the following people, the grade 9 Physical Science teachers, my father Mr Boston Likando, my husband Mr. Oosthuizen Linanga, my sister Jane and her son Amos, my three daughters Florence, Grace and Mukatimui. They were my pillars of support who kept the lamp burning throughout this academic journey.

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ABSTRACT

The examiners' reports for 2013-2018 indicated that learners consistently perform poorly in questions based on chemical changes. My assumption is that the reason why learners are challenged with understanding the topic of chemical changes could be due to the way this topic is taught. It is against this background that this study explored how grade 9 Physical Science teachers mediated learning of the topic of chemical changes. The study is underpinned by an interpretive paradigm. Within the interpretive paradigm, a qualitative case study research design was employed. It was conducted at two different schools in the Otjozondjupa region with two Physical Science teachers. Data were collected using semi-structured interviews, lesson observations, stimulated recall interviews, and teachers' reflections. The study is informed by Vygotsky's socio-cultural theory together with Shulman's pedagogical content knowledge as the theoretical frameworks. A thematic approach to data analysis was adopted. That is, qualitative data were analysed inductively to come up with sub-themes to form themes. Moreover, validation and trustworthiness were completed through data triangulation, member checking, and watching videotaped lessons with the participants.

The findings of this study revealed that the topic of chemical changes has many examples which can be used during mediation. Teachers seemed to be aware of integrating learners' experiences into their lessons. Furthermore, they were aware that they should improvise resources during mediation of learning. In contrast, during lesson observations, the findings revealed an imbalance between this awareness and the actual knowledge of using easily accessible materials, and the elicitation and integration of prior knowledge throughout the science lessons. Moreover, hands-on practical activities were lacking in the mediation process and instead, traditional methods of teaching tended to dominate. Nonetheless, teachers' reflections influenced them to analyse and strengthen their lessons. Thus, the study recommends that there is a need for teachers to have mentorships and platforms which can expose them to the knowledge of different types of easily accessible materials. This might strengthen their PCK. Teachers are also encouraged to do some reflections after very lesson as these have a potential to influence their pedagogical practices.

Key words: *Physical science; chemical change; prior knowledge; socio-cultural theory; pedagogical content knowledge*

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LIST OF ABBREVIATIONS AND/OR ACRONYMS

BEd -	Bachelor of Education with Honours
CK-	Content Knowledge
COVID-19-	Coronavirus
IAE -	International Association for the Evaluation of International Achievement
IK -	Indigenous Knowledge
JSSEE -	Junior Secondary Semi-External Examinations
LCE -	Learner Centred Education
MKO -	More Knowledgeable Other
MoE -	Ministry of Education
NCBE -	National Curriculum for Basic Education
NIED -	National Institute for Educational Development
PEEOE -	Predict, Explain, Explore, Observe, Explain
PCK -	Pedagogical Content Knowledge
PK -	Prior Knowledge
SACMEQ -	Southern African Consortium for Monitoring of Education Quality
SMK -	Subject Matter Knowledge
STI -	Stimulated Recall Interviews
TIMSS -	Trend in International Mathematics and Science Study
TMESD-	Transformational Model of Education for Sustainable Development
TSPCK -	Topic Specific Pedagogical Content Knowledge
UNESCO -	United Nations Educational, Scientific and Cultural Organization
ZPD -	Zone of Proximal Development

CHAPTER ONE: SITUATING THE STUDY

1.1 Introduction

The main goal of this study was to explore how grade 9 Physical Science teachers mediate learning of the topic of chemical changes. It was triggered and motivated by examiners' reports (2013-2018) which indicated that learners usually perform poorly on questions based on the topic of chemical changes. Furthermore, from my personal experience, I have observed that learners usually confuse the content of physical change with that of chemical change. It is for this reason that the study aimed to unearth or surface the underlying issues on how teachers mediate learning of this topic.

In the first section of this chapter, the background of the study is explained. It is followed by personal experience, the statement of the problem, and significance of the study. A summary of the research goal, objectives, and research questions of the study are highlighted. Additionally, data gathering techniques are stated together with the key concepts and the outline of the thesis. The chapter ends with a chapter summary. This study was conducted during the Coronavirus pandemic (COVID-19).

1.2 Background of Study

Science education is still faced with a number of challenges. As a result, poor performance in science subjects tends to be a challenge worldwide (United Nations Educational, Scientific and Cultural Organization (UNESCO, 2011). The Trends in International Mathematics and Science Study (TIMSS) includes the evaluation of performance in mathematics and science of South African learners. Martin, Mullis, Gonzalez, and Chrostowski (2003) explain the TIMSS as a project of the International Association for the Evaluation of International Achievement (IEA). They state that the project is run by a group of stakeholders who conduct studies on national achievements with the purpose of providing data on performance in mathematics and science. These TIMSS reports provide the achievements of the learners based on different types of curriculum, instructional practices, and school environments.

The TIMSS (2011) in which South Africa and Botswana took part revealed that learners from these countries are faced with problems such as lack of scientific reasoning and knowledge application. The report gives a clear indication that teaching and learning of mathematics and science is worrisome and should be improved. Namibia is no exception, even though it did not take part in the research study. However, it took part in the Southern African Consortium for Monitoring Education Quality (SACMEQ). The performance in mathematics and science between 2004-2011 was unimpressive compared to other southern African countries, including Namibia where this study was conducted.

Science is an important subject in the school curriculum. It is considered to be part of the educational foundation for children. Furthermore, it allows learners to explore their environment and be curious to learn new things. Based on the views of Nida, Rahayu, and Eilks (2020) on the importance of science, they point out that science is one of the subjects which focuses on the conceptual understanding of scientific content. This is for the purpose of application and how science influences the development of society. They further articulate that to prepare learners for societal development, they should be prepared in such a way that they acquire skills which enable them to engage in science-based discourses. As a result, teachers have to apply certain teaching strategies in their classrooms for learners to acquire appropriate skills.

The chemistry section of science can also be used as a vehicle for learners to develop skills. This chemistry section deals with everything which has mass and occupies and contributes to everything around us. Chemistry section contributes "to our existence, our culture and our quality of life" (Çetingül & Geban, 2005, p. 70). Furthermore, Han, Li and Sin (2012) explain that chemistry provides the understanding of properties of all materials and changes they undergo. It leads to the understanding of many practical applications, discoveries, and developments. Moreover, Adu-Gyamfi and Ampiah (2019) add that chemistry topics in Gambia and Nigeria are considered to be important as they contribute to the improvement of scientific reasoning.

Despite the significance of science, in particular chemistry as alluded to above, there are however some concerns about chemistry being regarded as a difficult subject by learners. For instance, Laudonia and Eilks (2018) point out that in southern Switzerland, chemistry is not popular among learners in higher grades due to reasons such as low motivation and misconceptions. Moreover, in Malaysia, Han, Li, and Sin (2012) explain that an observation was made that learners normally consider chemistry as difficult which results in discouraging them to continue

with the subject at university level. They further point out that teachers also seem to lack specific guidance for the changes in the curriculum and pedagogies which are vital to teaching and learning of chemistry (Shulman, 1986).

Extending on Shulman's (1987) seminal work, Davies and Smithey (2009) point out that teachers should understand learners' needs, respond to diversity, and encourage all learners to participate fully in learning these chemistry topics. Research findings by Broman, Ekberg, and Johnels (2011) indicate that Swedish learners are not interested in taking chemistry in higher grades because of the abstractness of topics, insufficient understanding of model-based problems, and work overload. As a result, these scholars propose that teachers should play a role in teaching and motivating learners to be interested in pursuing chemistry topics. That is, teachers need to have good insight into the topic so that learners can get a complete understanding of scientific concepts in those topics. Holistic knowledge of the topic might enable teachers to transform subject matter knowledge to make it understandable during teaching and learning of science lessons (Shulman, 1986; 1987).

For this reason, Shulman (1986; 1987) emphasises that there is a need for teachers to transform subject matter knowledge so that it can be comprehensible and accessible to learners. Moreover, teachers should also reflect on their own teaching so that they critically think about developing new pedagogies. Concurring, Laudonia and Eilks (2018) reiterate that chemistry teachers should consider the subject as motivation and make it more relevant to learners for them to pursue it further. That is, difficulties in chemistry topics should be unpacked by science teachers who are competent and eager to work.

Among the chemistry topics which are regarded as challenging to learners is the topic of chemical changes which is the focus of this study. This topic is introduced from the earlier seventh and eighth grades. Johnstone (2006) explains that learners do not make clear distinctions between physical change and chemical change. He further points out that learners do not consider chemical reactions as complete transformations of a reaction but regard them as a change of state in matter which leads to misunderstandings in the topic. Research findings from Taber and De Jong (2013) point out that when learners are being taught about the topic of chemical changes, they tend to interpret chemical reactions as a process of modification in which chemical change is seen as physical change. They further state that learners normally interpret the product of a chemical change as a mixture where the original substances still persist (Taber & De Jong, 2013).

As a result, teachers should be engaged in a reflective space which enables them to think about their teaching and completed work, and analyse their procedures, thoughts, strengths, and weaknesses in order to improve their planning (Lane, McMaster, Adnum, & Cavanagh, 2014). In Namibia, it seems that teachers are also struggling with making the topic of chemical changes comprehensible and accessible to learners.

Before independence, Namibia was characterised by segregation and separate development for different ethnic groups (Tjikuua, 2000). Tjikuua further states that in schools, science and mathematics were chosen by few learners. However, after independence, the Ministry of Education Sport and Culture recognised science education as one of the pillars which deals with "understanding scientific process, the nature of scientific knowledge and ability to apply scientific knowledge and skills" (Ministry of Education [MoE], 1993, p. 12). As a result, changes were made to the Namibian curriculum in which mathematics and science were made compulsory for all learners.

Moreover, the Namibian Curriculum for Basic Education (NCBE, 2016) adopted Learner-Centred Education (LCE) as part of its educational reform (Nyambe, 2008). Nyambe further explained learner-centred education as an approach which places a learner at the centre of learning. This means that a learner is responsible for learning while on the other hand a teacher is responsible for facilitating learning. Additionally, the MoE (2010) pointed that learners learn best when they are actively involved in the learning process. Hence, the LCE is central to the NCBE which emphasises that teachers are expected to mediate learning to ensure active participation by learners (Sedlacek & Sedova, 2017). Even though the NCBE adopted this approach, it seems that teachers are still challenged with its practice. For instance, Nyambe and Wilmot (2012) in their study conducted on teacher educators, revealed that there is a mismatch in the description of LCE and the practice at implementation level. This indicates that teachers still need some skills on the practice of LCE. In light of this, the NCBE (2016) also recommends the use of local materials, and values what learners bring into the classroom. This suggests that teachers should consider the use of easily accessible materials (Asheela, 2017; Hashondili, 2020; Ndevahoma, 2019; Shinana, 2019) and learners' cultural capital (Shizha, 2013).

For instance, Shizha (2013) expresses that pedagogical practices should acknowledge and accept cultural differences in the classrooms as they play a major role towards the understanding of learners. He expressed that the African curriculum inherited the former colonial government's

outlook which reflects colonial educational paradigms. As a result, the science that is being taught in most schools lacks an African identity (Shizha, 2013). Yet, science education is considered to be one of the important aspects which sharpens the development of the world (Brock-Utne, 2001).

Extending on Vygotsky's (1978) seminal work and concurring with Shizha (2013) and Brock-Utne (2001), Mavuru and Ramnarain (2017) emphasise the importance of taking into consideration learners' socio-cultural contexts. These scholars believe that learners are intellectually generative individuals with the capacity of learning through interactions and constructing new knowledge. That is, these scholars believe that learners have their own needs, own ways of learning, pace of learning, and different experiences. For those reasons, the Namibian curriculum also recommends that teachers utilise learners' socio-cultural contexts during teaching and learning.

In light of the foregoing discussions, Namibia developed its National Curriculum for Basic Education (NCBE, 2016) based on the constitution and the Education Act of 2001. The NCBE (2016) identifies natural science subjects as one of the key learning areas that empowers learners to think and take responsibility for their own learning. Essentially, the curriculum (NCBE, 2016) strives to transform Namibia into a knowledge-based society characterised by effective and wise utilisation of existing knowledge and the creation of new knowledge. As alluded to earlier, the curriculum is designed with the philosophy of learner-centred education. Learner-centred education, as explained by the Ministry of Education (MoE,2009), allows learners to bring out their experiences which are viewed as the starting point of teaching and learning by teachers.

Furthermore, the curriculum makes some provisions for teachers in that they can use what is within their environment which can be everyday items which can be collected and utilised to enhance teaching and learning. It further points out that teachers should improvise the learning and supporting materials provided they are safe and hygienic for the learners. Having said that, the topic of chemical changes which is the focus of this study, may be one of the science topics which integrates some of the easily accessible materials from the environment.

The Physical Science syllabus for grade 9 in Namibian schools has five main topics which are for both physics and chemistry. The second topic is about matter and materials which has a sub-topic of chemical changes which is part of chemistry. The objectives outlined in the syllabus is that learners should be able to:

- “Describe the process of a chemical change and compare it to a physical change;
- Outline the course of chemical change as
  - reactant(s) $\longrightarrow$ products or
  - A + B $\longrightarrow$ C + D
  - apply these terms to various examples;
- Describe experiments to illustrate the difference between a physical change (e.g. boiling water) and a chemical change (e.g. striking a match);
- Identify new substances formed by chemical reactions and discuss that the properties of the reactants differ completely from those of the product(s);
- Outline that a chemical reaction involves a change in energy;
- Distinguish between exothermic reactions (energy given out) and endothermic reactions (energy taken in);
- Outline that exothermic reactions often need an initial input of energy to start them off but that after this will proceed spontaneously;
- Outline reactions in which energy is spontaneously given off (e.g. the oxidation of a piece of sodium or the reaction of an organic substance with potassium permanganate);
- Suggest reactions such as burning of wood or the burning of magnesium which are exothermic reactions but require energy to start them off;
- Discuss the energy or temperature changes in some endothermic reactions such as heating baking powder to liberate carbon dioxide in the baking process and the reaction between sodium hydrogen carbonate and acid; and
- Write word equations for the reactions of chemical change”.

(MoE, 2015, p. 33)

Looking at what is outlined as the specific learning objectives to understand the topic, a variety of teaching methods together with the learning support materials should be used. At grade 9 level for instance, the assumption is that learners should have already been exposed to some of the competencies from the previous grades (prior knowledge) (Roschelle, 1995). They should possess the knowledge of states of matter and how they interact with each other. Therefore, teachers need to have comprehensive knowledge and a good understanding of the topic for the specific competencies to be achieved. For that reason, Iiyas and Saeed (2018) emphasise that teachers’ awareness regarding learners’ level of understanding plays an optimal role in the learning of the learners.

To determine whether the objectives of the syllabus are achieved or not, Namibian learners are assessed through national examinations. These examinations used to be facilitated at the end of grade 10 and 12. However, the latest Namibian curriculum review in 2015 changed these national examinations to be written at the end of grade 9, 11 and 12 (NCBE, 2015). At the end of each written examination, examiners' reports used to be prepared revealing how learners performed on specific questions. For instance, the examiners' reports for 2013-2017 for grade 10 and 2018 for grade 9 indicated that learners used to be challenged when answering questions of the topic chemical changes. For example, comments from examiners' reports (2013-2018) related to chemical changes topic were:

- Learners incorrectly identified physical changes as chemical changes;
- Learners failed to identify where heat energy is being absorbed or released from chemical changes;
- Learners failed to give a clear distinction between exothermic and endothermic reactions; and
- Poorly answered, learners failed to give clear properties of a chemical change.

In most cases, the examiners' reports used to relate learners' poor performance to lack of conceptual understanding during teaching and learning. Thus, the examiners' reports used to encourage teachers to use different kinds of teaching approaches including hands-on practical activities to enhance conceptual understanding of the topic. These reflections from examiners' reports and personal teaching experience triggered my interest to carry out a research study on the topic chemical changes.

1.3 Personal Experience

From my teaching experience, I have been challenged on how to incorporate learners' experiences and how to improvise using easily accessible materials in my teaching practice. Learners' experiences might be prior knowledge/cultural knowledge which learners possess when entering a learning environment. It might be significant to integrate these learners' experiences when mediating learning of the topic of chemical change. Furthermore, I found it difficult to carry out practical activities as my mind was only focused on materials and chemicals outlined in the textbook. The school where I am employed is a semi-rural school which is under

resourced and I found it difficult to acquire materials and equipment to be used to perform practical activities.

When I was accepted by Rhodes University for BEd (Honours) in 2017, I was introduced to three themes – language and science, prior knowledge, and indigenous knowledge – in relation to science education. I had little knowledge on how these three themes play an important role in teaching and learning of science. I became aware that language is also considered crucial when mediating learning of science lessons. That is, the teaching and learning of science is mediated through language. Furthermore, I was exposed on how to use easily accessible materials within the environment for learners to make sense of scientific concepts.

Moreover, indigenous knowledge and prior knowledge was brought to my attention when Asheela (2017) presented the preparation of [1]*Oshikundu*, an Oshiwambo traditional non-alcoholic beverage at the NIED (National Institute for Educational Development) in 2018. She used it to show scientific processes together with scientific concepts found in the preparation of the beverage. That experience was a revelation to me, that there are a lot of materials which are within our learning environments that can be used to enhance the teaching and learning of science in classrooms. Through my academic journey in the BEd (Honours) course, I learnt some strategies on how to use easily accessible materials, elicit, and integrate prior knowledge and indigenous knowledge into the teaching of science in the classroom. As a result, practical activities became a little easier for me to perform.

In addition, in 2019 when we visited Rhodes University for the research design course, I experienced how an indigenous practice of making [2]*Umqombothi*, an isiXhosa traditional brewed beverage, by mama Joyce Nolingo can be used to explain scientific processes and concepts in science lessons. It made me realise that elders possess a lot of cultural knowledge which can be used in classrooms for learners to value the importance of science and relate what is experienced at home with the science in the classroom. Some of the challenges which I experienced through my teaching practice became easier to address through my experiences at Rhodes University. The knowledge and experience which I gained might help to unpack and understand the topic of chemical change.

[1] *Oshikundu* is a traditional non-alcoholic beverage made by Oshiwambo people in Namibia.
[2] U*mqombothi* is a traditional alcoholic beverage made mostly by isiXhosa speaking people in South Africa.

1.4 Statement of the Problem

The topic of chemical changes is part of the theme ‘matter ‘and the topic itself is introduced at the senior primary and junior secondary levels. Understanding this topic clearly helps learners interpret and understand phenomenon around them. That is, they should be able to make sense of what is happening, how things work, and possibly formulate new knowledge. Inspired by the examiners’ reports, the findings from research studies and personal experiences triggered my interest to carry out this research study. For instance, as reported in the National Examiners’ reports (2013; 2015; 2016) for grade 10 and 2018 for grade 9, learners still find it difficult to acquire the learning objectives of the topic of chemical changes regardless of teaching which took place in grades 7, 8 and 9. As a result, learners usually perform poorly in questions on chemical changes at grade 10 level when they used to write national examinations, which has now changed to grade 11 examinations.

Studies conducted by Kanime (2015), Shifafure (2014) and Uushona (2013) in different science topics point out that lack of pedagogical content knowledge, inclusion of indigenous knowledge, and in-service training are some of the factors which contribute to poor performance and understanding in science lessons. Concurring, Asheela (2017) also attests that lack of experience on how to integrate learners’ experiences and the use of easily accessible materials into their classrooms affects learners’ understanding of science concepts. Thus, this study sought to look at the additional science topic of chemical change which seems to be challenging to learners. It is against this background that my study sought to understand how grade 9 Physical Science teachers mediate learning of the topic of chemical changes.

1.5 Rationale and Significance of the Study

The focus of the study was to understand how teachers mediate learning of the topic of chemical changes. By carrying out this research, teachers’ experiences might provide underlying issues to explain why learners do not learn science concepts easily in this topic. Furthermore, it might also provide me and the participants with an opportunity to explore a variety of teaching approaches and resources, in particular easily accessible resources as reiterated by Asheela, Ngcoza, and Sewry (2021) and examples to use when mediating learning of the topic of chemical changes. Moreover, the teachers involved in this study might also be afforded an opportunity to reflect on their own teaching practices which might ultimately help them to identify other alternatives to

improve their own teaching practices. Although the study is limited to teachers, the results of the study can also be useful to other educators in science education. For example, since the study looked at how teachers mediate learning, it can inform curriculum developers on how to address the topic when revising the curriculum. Furthermore, the study could be useful to those who would like to conduct research in the same area.

1.6 Research Goal, Objectives and Research Questions

The main goal of this study was to explore how grade 9 Physical Science teachers mediate learning of the topic of chemical changes. To achieve this goal, the following objectives and research questions were addressed.

1.6.1 Objectives of the Study

The objectives of the study were to ascertain:

1. Grade 9 Physical Science teachers' perspectives, experiences, and pedagogical insights on the topic of chemical changes.
2. How teachers mediate learning of the topic of chemical changes.
3. Lessons which appear from teachers' reflections after mediation of learning of the topic chemical changes.

1.6.2 Research questions

1. What are grade 9 Physical Science teachers' perspectives, experiences, and pedagogical insights regarding mediation of learning of the topic of chemical changes?

2. How do grade 9 Physical Science teachers mediate learning of the topic of chemical changes?

3. What lessons appear from teachers' reflections after mediation of learning of the topic chemical changes?

1.7 Theoretical and Analytical Framework

This study is informed by Vygotsky's socio-cultural theory and Shulman's Pedagogical Content Knowledge (PCK). Within PCK, the analytical framework is Topic Specific Pedagogical Content Knowledge (TSPCK) by Mavhunga and Rollnick (2013).

1.7.1 Theoretical framework: Socio-cultural theory

The study is informed by Vygotsky's socio-cultural theory which states that meaningful learning results from social interactions, and that culture and beliefs influence how individuals learn (Vygotsky, 1978). Within this theory, I focused on the following concepts: *mediation of learning*, *social interactions* and *zone of proximal development (ZPD).*

1.7.2 Analytical framework: Pedagogical content knowledge

In addition to socio-cultural theory, the analytical framework was TSPCK from Shulman's (1986; 1987) theory of PCK. TSPCK focuses on five components by Mavhunga and Rollnick (2013). The theory explains that in order to foster understanding, a teacher needs to present the Subject Matter Knowledge (SMK) in a way that ensures access to the learners. During the teaching process, examples should be drawn from learners' experiences in order to enhance the understanding of the subject content.

1.8 Data Gathering Techniques

- Semi-structured interviews;
- Lesson observations;
- Stimulated recall interviews; and
- Teachers' reflections.

1.9 Definition of Key Concepts

Chemical change: The process in which a substance is converted into one or more new compounds (Katmiat, Wiji, & Mulyani, 2017).

Indigenous knowledge: Knowledge and skills which are unique to a particular culture or community involving wisdom that has been developed and passed from generation to generation (Kibirige & Van Rooyen, 2006; Mapara, 2009).

Mediation: Central collaborative interactions taking place in the social set-up (Gibbons, 2003).

Physical Science: The study which deals with matter and energy and the changes they undergo.

Prior (everyday) knowledge: Experiences which learners brings into the classroom which originates from home, cultures, communities, and/or from previous grades.

Pedagogical Content Knowledge (PCK): The knowledge which teachers should possess in order to transform the subject content into being easily accessible to the learners (Shulman, 1986; 1987).

Socio-cultural theory: A theory which states that learning is a process and that society plays a role in creating meaning through social interactions (Vygotsky, 1978).

Social interactions: The process in which individuals interact with one another as well as the environment (Vygotsky, 1978).

Subject Matter Knowledge (SMK): The term used to describe the way in which information related to a specific topic is possessed.

1.10 Thesis Outline

The study was conducted in Namibia with two teachers in the Otjozondjupa region. These teachers were from combined schools with grades from pre-primary to grade 9. The thesis consists of six chapters and below is the overview of the chapters.

Chapter One: The chapter explained the background and context of the study. Thereafter, was the discussion of my personal experience, statement of the problem, and significance of the study. It was followed by the research goal, objectives, and research questions. Furthermore, the theoretical framework and analytical framework were outlined. The data gathering techniques were mentioned and the key concepts defined.

Chapter Two: This chapter engages the relevant literature of the topic. It discusses the literature in relation to the Namibian curriculum with the topic of chemical changes. Prior knowledge, indigenous knowledge, hands-on practical activities, and the role of language in science lessons are discussed. The theory underpinning the study is socio-cultural theory and the analytical framework is Topic Specific Pedagogical Content Knowledge (TSPCK) which form part of the discussions in this chapter.

Chapter Three: The chapter provides the research methodologies adopted in the study. The data gathering techniques and the reasons for choosing these techniques are justified. Examples of

data gathering techniques are semi-structured interviews, lesson observations, stimulated recall interviews, and teacher's reflective journals. Analysis of data and issues regarding ethics and validity are discussed in this chapter.

Chapter Four: This chapter aims to provide explanations from semi-structured interviews and lesson observations. Emerging themes and findings are discussed from these data gathering tools. The chapter provides detailed discussions in relation to theory and relevant literature.

Chapter Five: The chapter presents data generated from stimulated recall interviews and teacher's reflections. The empirical research findings are interpreted using the relevant literature and the theoretical framework of the study.

Chapter Six: Using the literature reviewed, this chapter deals with discussions of the findings and the themes that emerged from the study. The analysis of results from Chapter Four and Five are summarised. Recommendations, limitations of the study, personal reflections, and a conclusion are presented in this chapter.

1.11 Chapter Summary

In this chapter, the background of the study, statement of the problem, significance of the study, the research goal, research objective, research questions, and theoretical and analytical framework are discussed. Definitions of key concepts as well as the thesis outline are provided in order to give a clear understanding of the research and to enable the readers to easily navigate through the research.

CHAPTER TWO: LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Introduction

The main aim of this study was to explore how grade 9 Physical Science teachers mediate learning of the topic of chemical changes. It was triggered by examiner's reports, teaching, and personal experience. In the previous chapter, I discussed the context of the study. In this chapter, I review literature relevant to my study.

As of writing this chapter, I had not found any study in Namibia which investigated how grade 9 Physical Science teachers mediate learning of this topic. However, there is abundant literature on the topic of chemical changes, prior knowledge as well as indigenous knowledge which I will discuss first. Thereafter, I discuss the role of hands-on practical activities together with challenges associated with it. Furthermore, the role of language in science education is also discussed. Lastly, I provide the theoretical and analytical framework which underpins this study. The theoretical framework is socio-cultural theory and the analytical framework is from Shulman's PCK focusing in particular on the five components of TSPCK from Mavhunga and Rollnick (2013) which was used to complement socio-cultural theory.

2.2 The Topic of Chemical Changes

The Namibian Curriculum for Basic Education (NCBE, 2016) is an official document which guides teaching and learning in Namibian schools. This document provides guidance for uniformity in curriculum delivery in the entire country and outlines the structure for developing the syllabus, subject policy and learning materials and textbooks to be used in different subjects as supporting learning materials. The document reflects a certain number of issues such as prior knowledge, traditional knowledge/indigenous knowledge, practical activities/investigations, and easily accessible materials which should be taken into consideration when planning to teach and during teaching and learning (Asheela et al., 2021). Moreover, the use of easily accessible materials promotes the hands-on practical activities to help learners understand science concepts

(Asheela et al., 2021). The intended focus of this study was to explore how grade 9 Physical Science teachers mediate learning of the topic of chemical changes.

The Physical Science syllabus for grade 9 has a chemistry part which is regarded as difficult in the science field. Johnstone (2006) expresses that the difficulty of science might be rooted in how learning has been facilitated, the ability of human learning, as well as the intrinsic nature of the subject. Moreover, Ozmen (2010) points out that, the challenge of chemistry topics arises from its abstraction and scientific words from the school environment which are different from those in everyday life. Among topics which learners find difficult to understand in chemistry is the topic of chemical changes.

Essentially, this topic deals with understanding the properties of matter and how substances interact to form new substances (Namibia. MoE, Syllabus,2015). These changes occur when substances produce new combination of matter which are known as chemical reactions. Thus, more emphasis should be put on these reactions to explain chemical processes (Osterlund, Berg, & Ekborg, 2010). Some of these reactions are illustrated from prescribed textbooks by the ministry of education. For example, Solid Foundation Physical Science for grade 9 gives examples such as combustion, corrosion, and decomposition reactions as examples of chemical changes (Niekerk, 2016).

Based on that, learners enter the learning environment with experiences of many examples of chemical changes from everyday life without realising it (Osterlund et al., 2010). So, before teaching and learning took place, these experiences should be elicited. Moreover, these experiences might promote context-based learning which is in support of the learner centred approach (Ngman-Wara, 2016). Learners might construct scientific knowledge through social interactions and experiences and ideas from other fellow learners and teachers (Mavuru & Ramnarain, 2020). Ngman-Wara (2016) further explains that through context-based learning, the starting point for teaching should begin from everyday experiences to the type of content to be taught in the science lesson. Therefore, teachers have to identify some means on how to elicit and use these experiences from learners through context-based learning (Ghulum, & Nyberg, 2017; Mavuru & Ramnarain, 2020). Thereafter, they should also reflect on their own teaching practices which integrate these experiences as to understand their way of teaching (Macmillan & Schumacher, 2014).

Essentially, integration of real life/everyday experiences is in line with context-based learning as elegantly explained by Chikamori, Tanimura, and Ueno's (2019) Transformational Model of Education for Sustainable Development (TMESD) framework. To Chikamori et al. (2019), the TMESD framework is composed of three learning sub-processes: 'knowing the present', 'past-present (*retroduction*)' and the 'future-present (*retrodiction*)' (see Figure 2.1).

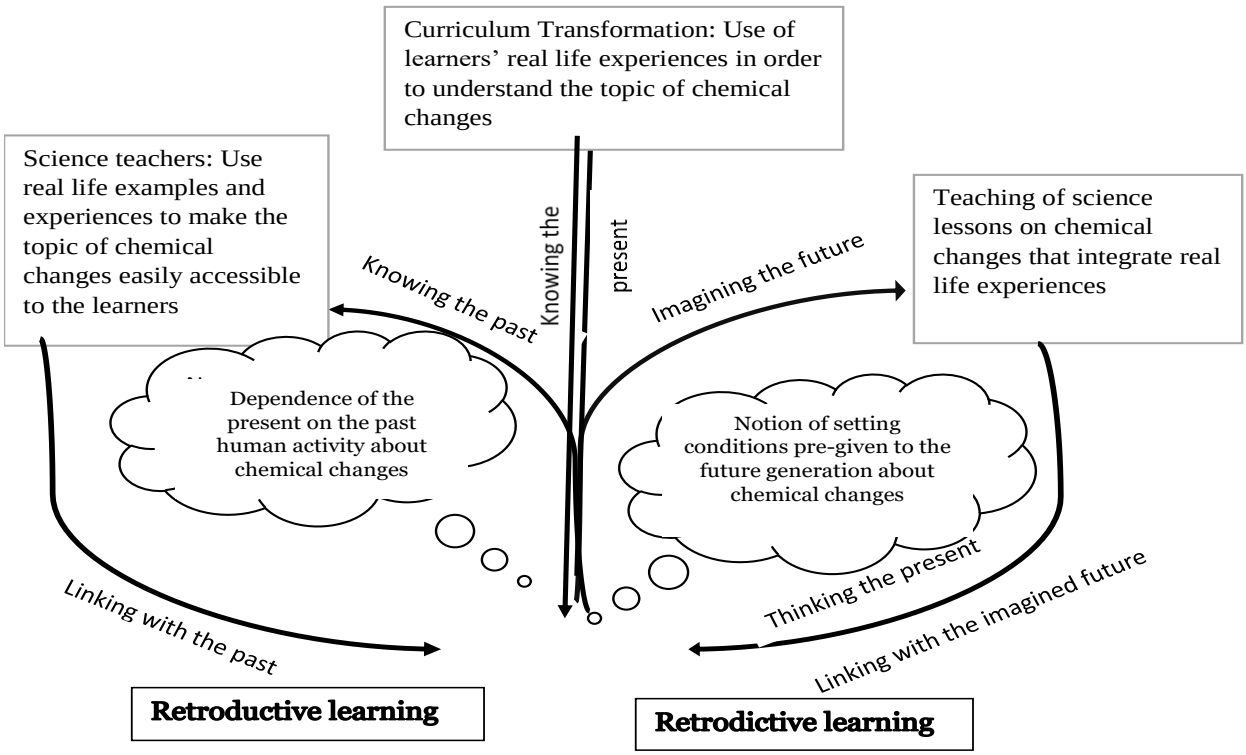

Figure 2.1: Shows the role of real life experiences from home in science classroom (adapted from Chikamori et al., 2019, p. 9)

The TMESD diagram in the context of this study illustrates how mediation of learning using learners' real life experiences of chemical changes could possibly take place in the three sub-processes. For instance, in the first place of knowing the present, the examiners' reports for 2013-2016 for grade 10 and 2018 for grade 9, indicate that learners are challenged when answering questions on this topic. They seem not to know the difference between physical change and chemical change. As a result, learners failed to identify which change could be reversed (Namibia. MoE, Examiner's Report, 2016). This could be compounded in part by the fact that science teachers themselves might not be aware that during the mediation of learning of the topic

of chemical changes they should consider learners' experiences and real examples, which are their past experiences from home or community.

Learners' past experiences play a crucial role in understanding the second process of TMESD. In this process, teachers should use their learners' experiences and choose those which can be integrated in the topic of chemical changes in order to make it easily accessible and relevant to their learners. These experiences determine the level of learners and how they might understand the topic. In light of this, Chikamori et al. (2019) explains that learners consider the present in relation to what they know from the past for them to understand new content. The chemical changes topic considers these experiences as it is not a simple concept to be learnt at once (Geban & Bayir, 2000). Moreover, learners are confused by the topic, especially chemical changes occurring in the real world (Geban & Bayir, 2000). As far as Chikamori et al. (2019) are concerned, once teachers enable learners to understand the topic of chemical changes they might be able to move from *retroductive* learning to the process of *retrodictive* learning. To these scholars, this is where learners will be able to understand most of the content and concepts related to chemical changes in the future. They might be able to identify and understand other science topics which feature the topic of chemical changes and other concepts extended further. Meanwhile, during teaching and learning of the topic of chemical changes, teachers should encompass some positive attitudes such as interest, enjoyment, value, and motivation (Osborne, Simon, & Collins, 2003).

Moreover, teachers need to create their own space where they can view their own lessons, analyse them, and know how learners understand the lessons (Lane et al., 2014). Thus, findings from Solsas' (2003) study point out that learners have conceptions of chemical change that do not pay attention to chemical facts studied in class and experimented in the laboratory. As a result, they are challenged to understand the content. That is, the lesson content taught in class should complement the laboratory experiments. Moreover, Palmer (2006) expresses that the chemical change concept has been stressed throughout the years, yet learners still confuse the concept with physical change. Concurring, Katmiati et al.'s (2017) study conducted in Nigeria revealed that learners do not have a clear interpretation of chemical changes from chemical reactions. These scholars further expressed that the mental model of learners is affected by previous knowledge/experiences acquired by the learners. As there is a need for learners to have an attitude of understanding the value of science in everyday life (Kaya & Ebenezer, 2007), it was important to carry out this research study in order to gain more insights on the issue.

Teachers should be aware of the challenges learners face regarding the topic of chemical changes. Knowing these challenges might be done through writing reflections after every lesson taught in order to create awareness (Killen, 2015). Through knowing, teachers might have an opportunity to change how they plan and do research on how to teach the topic effectively. Reflections might allow teachers to improve on their lessons which could result in learners having a better understanding of the content (Chikamori, Ono, & Rogan, 2013). Additionally, the aspect which cannot be ignored is the knowledge which teachers should possess. Shulman (1986; 1987) terms such knowledge as Pedagogical Content Knowledge (PCK). Shulman (1986; 1987) identifies this knowledge as one a basis which teachers should possess in order to teach effectively. The PCK of teachers might assist them on how to transform specific competencies to be achieved into easy methods of pedagogies for learners to understand the content. PCK is believed to be the knowledge that teachers develop over time and through experience, about how to teach particular content in particular ways in order to enhance learners' understanding (Shulman, 1987). Shulman (1986; 1987) further describes other factors that affect PCK such as Subject Matter Knowledge (SMK) which he identifies as 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. Shulman (1986; 1987) also identifies that learners' characteristics and teaching practice should accommodate learners' individual differences during teaching and learning. The knowledge of PCK helps teachers analyse the science topics to be taught and their teaching practices (Loughram, Berry, & Mulhall, 2006). The content desired to be taught to the learners has to be planned together with the capabilities of learners. Furthermore, Chani, Chikunda, Ngcoza, and Sewry (2018) point out that the limited subject matter knowledge affects the pedagogical content knowledge of teachers which impacts on how they prepare lessons. Indeed, according to Shulman, SMK precedes PCK. Moreover, Park (2015) expresses that the PCK knowledge presents the knowledge which teachers use in the process of teaching. Park (2015) further alludes that they use this knowledge in planning lessons, choosing supporting materials, and to guide them in supporting learners.

Geban and Bayir (2000) articulate that teachers should plan and teach in such a way that learners appreciate the relevance of the topic with that of the real world. Moreover, teachers should not neglect application in everyday life. That is why, Osterlund et al. (2010) explain that teachers normally pay attention to what is illustrated in the textbooks without considering what is outside

the classroom environment. They further state that teachers should continue stating applications and values not realised by the learners for them to see the need of science topics. As a result, teachers should plan activities which incorporate everyday applications and experiences from learners. This might encourage active participation, positive attitudes, and change the way they view science content. The learners' preconceptions will shift to a different level which might influence the way they learn if they recognise the relevance. Furthermore, Geban and Bayer (2000) point out on the notion of classroom instructions, that they should support learners to change from passively receiving information to actively examining the content. Based on the outline in the curriculum document, the topic of chemical changes might include the use of prior knowledge which might be in the form of cultural knowledge/indigenous knowledge in order to enhance the teaching and learning of the topic.

2.3 Prior Knowledge in the Namibian Curriculum

The National Curriculum for Basic Education (NCBE, 2016) is based on the notion that learning starts with what learners already know as they do not come as empty vessels into the classrooms. They possess knowledge accumulated from their everyday experiences. That is, the fundamental point of the learning process which should start with the existence of prior knowledge to be transformed into new knowledge (NCBE, 2016). Relating what learners are familiar with in the learning environment enables them to explore and develop scientific knowledge.

In light of this, Roschelle (1995) defines prior knowledge as the knowledge learners have before capturing new information. That is, the type of knowledge learners enter with into the classrooms before teaching and learning takes place. Roschelle (1995) further describes this knowledge as the foundation of new knowledge which coordinates old knowledge with new knowledge. He contends that it will be difficult to learn with the absence of prior knowledge. Thus, the differences in cultural backgrounds and beliefs position learners to be individually unique and construct meanings based on their differences. Based on that, teachers should elicit this knowledge from them in order to know what kind of learners they have and how they interpret science concepts. They have to elicit this knowledge by trying different approaches and reflect on how learners respond so that better strategies can be identified to improve their teaching practices.

The assumption of this knowledge is that it helps learners to construct new ideas during the learning process as science is something which deals with what forms part of our everyday life. Everyday life in science is embedded in science classroom practices which might be found in different types of activities planned by teachers (Erinosho, 2013). As a result, teachers have to design tasks which will enable learners to make some connections between what they already know and the new information intended to be learnt while actively engaging in teaching and learning (Kuhlane, 2011). Considering prior knowledge could also help teachers to plan and work with learners from different backgrounds. Without considering this knowledge, learners might have prior knowledge on what is planned to be taught and it might become boring to them. Thus, it is imperative for teachers to take into consideration this kind of knowledge. Moreover, Kibirige and Van Rooyen (2006) explain that this knowledge provides teachers with an opportunity to understand their learners and avoid repetition of the content known by the learners. That is why, the Namibian Curriculum (2016) emphasises the use of everyday knowledge and experiences.

Science is a complex subject which consists of terminologies which are unfamiliar to the learners. Making use of prior knowledge is needed in science lessons as it has some benefits associated to it. For instance, the study conducted by Stears, Malcolm, and Knowles (2003) in South Africa points out the relationship between prior knowledge and school science, that learners are actively involved in teaching and learning. Furthermore, Kasanda, Lubben, Gaoseb, Marenga, and Kapanda (2005) in their study conducted in Namibian Secondary Schools found that integrating learners' experiences in the classroom empowers them and it is a successful technique in learning to understand scientific concepts. Integration of learners' experiences engage learners to be part of the teaching and learning process. Concurring, in her study conducted in South Africa, Kuhlane (2011) concludes that inclusion of prior knowledge facilitates meaningful learning for learners to acquire science concepts better. Her views correspond with Enghono's (2013) study, that meaningful learning takes place when learners are fully engaged in the teaching and learning process.

Based on the benefits of prior knowledge, teachers have to plan their lessons while considering the learners' prior knowledge with caution. Taylor (1999) cautions that when integrating prior knowledge, care should be taken not to foreground it at the expense of conceptual knowledge and in-depth study of science concepts. Thus, teaching should be designed on the basis of learners' experiences with consideration. These everyday experiences can be refined and be

integrated effectively, as Rennie (2011) affirms that relating science knowledge and skills to everyday experiences enhances sense making of science content and learning.

Despite the advantages of prior knowledge in teaching and learning, Roschelle (1995) warns that sometimes prior knowledge can provide some misconceptions. In support, Taylor (1999) also explains that prior knowledge can inhibit meaningful learning if that knowledge is irrelevant. However, Roschelle (1995) acknowledges that neglecting prior knowledge can result in learners learning something opposed from the teacher's intensions. Thus, Stears et al. (2003) affirm that in order for learners to gain appropriate skills and knowledge, they should be involved in the presentations of the background of the lesson and shift to the new science information to be learnt. Prior knowledge can be in the form of local or indigenous knowledge (IK).

2.4 Indigenous Knowledge in the Namibian Curriculum

The Namibian Curriculum (2016) acknowledges the social and cultural aspects of learners. This aspect is considered to be local or indigenous knowledge (IK), which is directed towards cultural practices which might be utilised to enhance the understanding of science concepts. It further explains that it is vital to include the IK in teaching and learning to build from existing knowledge in creation of new knowledge. The focus of the study explored some of these indigenous practices in the classroom.

Indigenous knowledge **(**IK) is defined by Kibirige and Van Rooyen (2006) as the contextualised knowledge accumulated over a longer period of time and passed from generation to generation. Meanwhile, Klein (2011) considers this knowledge as a large body of knowledge with skills that have been developed from outside the education system and enabled people to survive and overcome challenges. Furthermore, Klein (2011) argues that this kind of knowledge can be integrated in classroom teachings by drawing on these valuable skills and knowledge. Similarly, Shizha (2013) adds that indigenous knowledge is what indigenous people already know and what they do from generation to generation. Meaning that, this knowledge is based on specific historical cultural knowledge which differs from context to context. Moreover, Erinosho (2013) states that cultural knowledge forms part of the learner's prior knowledge and can be used to contextualise the science concepts.

Effective science learning can be realised through the integration of cultural experiences from the learners or knowledgeable indigenous people from the communities. Aikenhead and Jegede

(1999) regard this integration as border crossing since it bridges the gap between home and school science. Furthermore, Aikenhead and Jegede (1999) assert that learners are likely to fail science because they fail to cross cultural boundaries between school science and indigenous knowledge. In addition, Kibirige and Van Rooyen (2006) consider this kind of knowledge as paramount because it practically engage learners with science within the environment. Cultural knowledge enhances learning through social interactions with learners and the community, thus encouraging sense making and meaningful learning (Vygotsky, 1978).

Research studies by Kibirige and Van Rooyen (2006), Mapara (2009), Mukwambo, Ngcoza, and Chikunda (2014) and Ogunniyi (2008) highlight a number of benefits on integration of IK in science lessons. These scholars encourage the integration of IK as it has the potential to promote participation, capture learners' interest, help in the development of science concepts and the recognition of the learners, community and teachers' cultures. In addition, Kibirige and Van Rooyen (2006) indicate that IK can be used as the starting point to explore more concepts associated with westernised science. As a result, Ogunniyi and Ogawa (2008) and Mukwambo et al. (2014) assert that the IK and western science should complement each other for better understanding of scientific phenomenon.

Bringing in these cultural aspects might provide opportunities to the learners who are culturally knowledgeable to strengthen their understanding of real world science. In addition to that, Shizha (2013) explains that practices in the classroom should reflect social and cultural contexts while at the same time should not ignore meeting current societal needs. Moreover, Barnhardt (2015) articulates that knowledgeable learners in schools who are grounded in cultural heritage and traditions in their communities might be able to understand and demonstrate how their cultural knowledge is related to the formal education system. Indeed, this might play a role in learners seeing the importance of science in everyday life situations. Meanwhile, Ronoh (2017) stipulates that the role of IK cannot be ignored even though the society where we find ourselves is rapidly changing.

Even though IK adds value to teaching and learning, Mukwambo et al. (2014) caution that proper examination of IK should be done before it is used in teaching and learning so that contradictions and misconceptions are pointed out. In addition, although the curriculum calls for teachers to include IK, the syllabus and textbooks in use do not document IK as it lacks scientific proof (Shizha, 2007). Thus, Kibirige and Van Rooyen (2006) posit that IK is orally transmitted and IK

practices are done through trial and error and are not scientifically proven. As a result, teachers tend to stick to what is written in the textbook and ignore the use of IK (Mapara, 2009; Webb, 2013). However, Ronoh (2017) posits that considering this knowledge brings about a sense of worthiness in science education. It might ease the challenges of some science topics, in which the topic of chemical changes is not an exception. The teaching of the topic of chemical changes may also include the use of hands-on practical activities.

2.5 Role of Hands-on Practical Activities in Teaching and Learning of Science

Hands-on practical activities form an essential component in teaching and learning of science. The NCBE (2016) outlines that in order to meet the requirements of teaching Natural Science subjects, learners should be empowered with scientific knowledge such as to investigate, observe, to formulate hypotheses, and make deductions. The Namibian Physical Science Syllabus for grade 8 and 9 (Namibia. MoE, 2016) stipulates that learners should be exposed to hands-on practical activities and demonstrations which are regarded as a minimum requirement for each topic. As a result, learners are required to perform practical activities which might be an initiator for them to obtain those skills.

Millar (2010) describes practical activities as any kind of teaching where learners are given the opportunity to observe and physically handle objects. Performing practical activities while handling objects allows learners to interact with materials and with one another. Ignoring the fact of not performing practical work might have a negative impact on the learners' understanding. For example, the examiner's report for Junior Secondary Semi-External (JSSEE, 2018, p,49) for Grade 9, explains that "it was observed that some learners lost marks for questions that require practical activities". Practical activities should be considered as important during teaching and learning. The practical activities may assist learners to visualise what is taught in science lessons. Vauva, Janjic-Watrich, Loerke, Phillips, Norris, and Macnab (2011) explain visualisation as the formation of mental images which can be used to create interpretations and presentations. Moreover, Lioyd (2015) defines visualisation as a language of images which uses shapes, colours, forms, lines, patterns, objects, people, and numbers. Visualisation enables learners to recognise and understand ideas which are conveyed through visual actions and pictures. This can be achieved through hands-on practical activities and observations. Asheela et al. (2021) supplements that hands-on practical activities enable learners to create a link between observations and ideas/theories of science.

Teacher are expected to create lesson plans and activities that will reflect visualisation and hands-on practical activities. Moreover, Woodley (2009) alludes that the "effect practical work enable students to build a bridge between what they can see and scientific ideas that account for observations" (p. 50). Woodley further explains that the purpose of practical work is to help learners with understanding science concepts and to make sense of them. Through predicting, experimenting, and explaining, learners will be engaged in the lesson which could possibly yield meaningful understandings about science concepts. Woodley (2009) adds that the hands-on practical activities support the development of practical skills which might enable learners to make sense of science concepts.

Extending on Maselwa and Ngcoza's (2003) seminal work, Asheela et al. (2021) articulates that effectiveness and skill development is based on 'hands on' and 'minds on' practical activities. They further suggest the approach of Predict-Explain, Explore, Observe, and Explain (PEEOE) which might be useful to employ during the performing of practical activities. Concurring, Okoye (2013) also notes that practical activities keep learners busy and stimulates thinking of students beforehand so that the main objective of answering the questions is achieved. In addition, Etiubon and Udoh (2017) express that practical activities provide students with opportunities to use their minds and thinking to discover general laws and principles in science. These practical activities can be performed by improvising science materials in the absence of original materials (Asare, Parker, & Osei-Himah, 2020). This might enable learners to not only memorise facts but understand the phenomenon.

Through hands-on practical activities, learners may gain an opportunity to manipulate objects to be used during teaching and learning. Furthermore, Abrahams and Millar (2008) affirm that learners will find practical activities enjoyable, and they will engage learning at different levels and challenge them mentally in order to think critically. It is as also explained by Treagust, Duit, and Nieswandt (2000) that students require some sort of exposure to scientific concepts several times so that learning is strengthened by re-teaching the concepts in different ways. Re-teaching might also be done after teachers critically reflect on lessons in order to improve on teaching practice (Chikamori et al., 2013). Reflections is an important tool to be considered after teaching.

Practical activities play a vital role in teaching science. Thus, Etiubon and Udoh (2017) advocate that science learning is practically oriented which requires practical activities in the laboratory in which broad-based experiences will widen student's knowledge in many topics. These activities might provide learners with opportunities to learn meaningfully. If organised properly in the classroom, these activities might possibly improve learning and skill development. Teaching and learning should be a participatory approach which involves both learners and the teacher. Kusi (2017, p. 26) also notes that "teaching and learning maybe interesting and productive when tutors engage and involve students to take active participation of the learning process". Woodley (2009, p. 50) summarises the importance of practical activities.

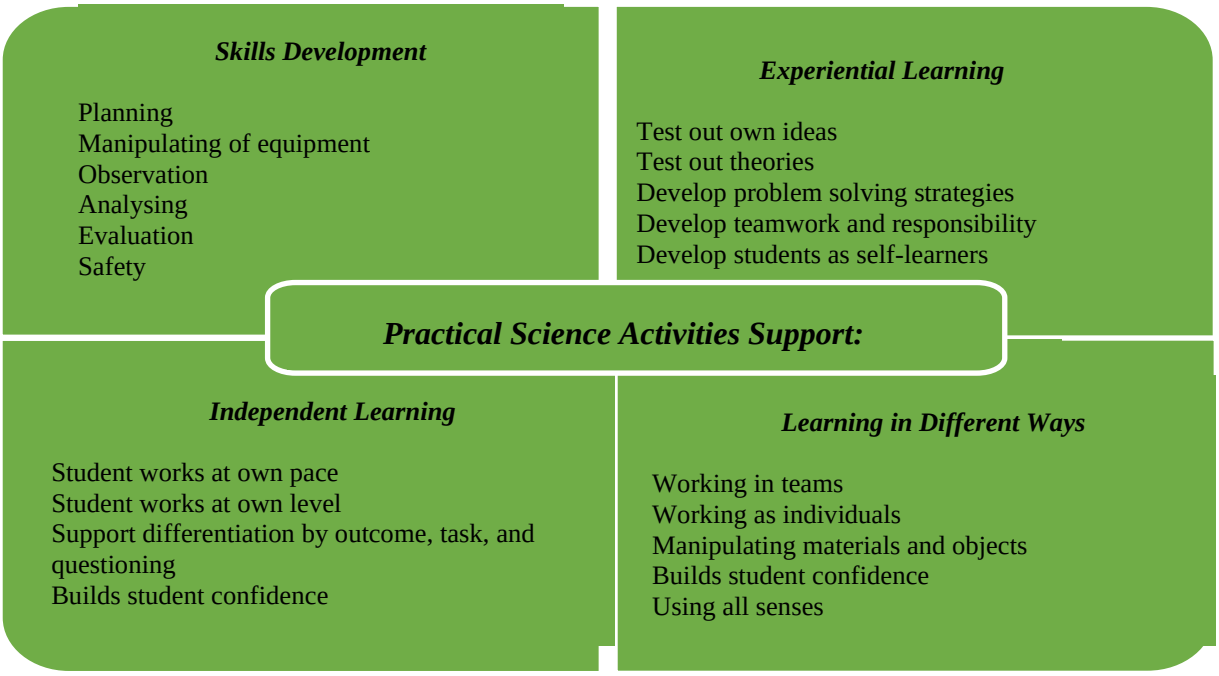

Figure 2.2: Summary of the importance of practical activities (adapted from Woodley, 2009, p. 50)

Drawing from Figure 2.3, Woodley (2009, p. 50) indicates that if practical activities are planned and well-organised, skills development is enhanced such as manipulating of equipment, observation, and analysing. Moreover, to make practical activities a better learning experience to develop these scientific skills and knowledge, factors such as practical exposure and the responsibility of learners to learn in order for them to become active participants should be taken into consideration at all times (Sedlacek & Sedova, 2017).

Practical activities improve the level of understanding science in the classrooms. However, Hodson (1990) bemoans that sometimes practical activities are unproductive and not carried out

adequately, as teachers use practical activities without proper planning. Asheela et al. (2021) articulate that effectiveness use of practical activities help learners to develop important skills and understand the process of scientific investigations. Moreover, Abraham and Millar (2008) also state that practical activities enable learners to make connections from scientific knowledge learnt in science lessons to everyday scientific applications. However, time constraint is a challenge together with pedagogical knowledge when teaching science lessons (Asare et al., 2018). After teaching and learning of science lessons, a reflect space may also be needed for teachers and learners.

2.6 The Importance of Reflective Space after Teaching and Learning of Science Lessons

A reflective space is a space where teachers have an opportunity to learn from their own teaching experiences and the experiences of others (Lane et al., 2014; Nhase, 2019). Teachers carefully analyse their lessons by looking at the strengths, weaknesses and how to improve on their lessons. Learners may as well be afforded an opportunity to find out what they have learnt from science lessons and challenges faced. The reflective practice might enable teachers to know and understand their learners better. Trif and Popescu (2013) point out that reflections enable teachers to work on their strengths and weaknesses in order to improve on their planning and teaching methods. Additionally, Chikamori et al. (2013) also note that the importance of critical reflections allows teachers to improve on their lessons for the betterment of their learners' knowledge and learning. Reflections might also help teachers to be aware of their own teaching practices and help learners to develop self-confidence. The language in use during teaching and learning also plays a role in the classroom.

2.7 The Role of Language in Science Lessons

Language plays an important role in science lessons. Vygotsky (1978) explains that language influences the way a person thinks during social interactions. When learners are engaged in teaching and learning, it is a language which helps them with formation of concepts. Wellington and Osborne (2001) state that "thought requires language, language requires thought" (p. 3). They further express that learning science in many ways is like learning a new language. Thus, language mediates thinking and learning. Learners normally think in their own language which is embedded in culture as a mediating tool and this can shape people's thinking (Leach & Scott, 2003). English is the language used during discussions and instructions. The English language

poses a challenge to the learners as Brock-Utne (2001) articulates that during teaching and learning, language poses a challenge to the understanding of learners.

Everyday language might also pose challenges to the learners when they learn scientific language as science language is different from the language used in everyday communication. Poor understanding of science language may lead to poor reasoning in science topics as learners are faced with the challenge of learning science in the language which is not their own. Learners try to learn the language of instruction while at the same time trying to learn science (Mavuru & Ramnarain, 2017; Msimanga & Lelliott, 2014). Written or oral language is required for teaching and learning science. Thus, Lemke (2001) proposes that learners should be given more opportunity to talk in order for them to develop the language of science. The learners' language, teachers' language, and scientific language all should complement each other and play a complex role in comprehending science concepts (Khurana & Shama, 2015). Teachers have the responsibility to direct learners to move from everyday language to scientific language. Science has similar concepts to everyday spoken language, though they have different meanings. Teachers have to deal with familiar words which give new meaning in science contexts. Science teachers also need to design a variety of tools and how to use them to develop learners' understanding in science. The significance of language in my proposed study is very important as teachers have to deal with learners' use of everyday language and scientific language when teaching the topic of chemical changes.

2.8 Theoretical and Analytical Framework

Merriam (2009) explains that a theoretical or conceptual framework is a structure on which a research project is based. It influences every aspect of the research derived from concepts, theories, and literature. This study was informed by Vygotsky's socio-cultural theory and Shulman's pedagogical content knowledge with the focus of topic specific pedagogical content knowledge (TSPCK) from Mavhunga and Rollnick (2013). Each of the theories is discussed below.

2.8.1 Theoretical framework: Socio-cultural theory

Vygotsky (1978) stipulates that knowledge is viewed as a human product, socially and culturally constructed in which individuals create meaning through social interactions. Vygotsky further points out that meaningful learning takes place when human beings engage in social interactions

based on their environment and culture. This theory suggests that the construction of knowledge results from a dynamic view of interactions between individuals and society. Culture and beliefs sharpen how individuals learn (Vygotsky, 1978). The theory further emphasises the importance of society and that sense making is realised through social interactions.

Vygotsky (1978) strongly argues that there is a link between social interactions and human development in terms of learning and environment. He further articulates that culture affects and sharpens cognitive development because the social environment in which human beings grow up influences their thinking. Meanwhile, these environments contain many opportunities for human beings to gain knowledge from one another. The gaining of knowledge is a process which does not take place with an individual but happens when these individuals are engaged in social interactions. Lave and Wenger (1991) concur with this theory by stating that learning is embedded in societies in which individual learning takes place in social actions and interactions which is termed as a community of practice. That is, the community plays an important role in sense making through social interactions.

In addition, Vygotsky (1978) further explains that this theory is the social process of learning and is based on the understanding of human intelligence in society and culture. Furthermore, McRobbie and Tobin (1997) posit that the socio-cultural perspective has three crucial components, namely, *involvement*, *autonomy*, and *relevance*. The active involvement during the mediation of learning of the topic of chemical change might contribute to better understanding of the topic. Autonomy is learners having control over their own learning and relevance is teachers who incorporate learners' socio-cultural contexts in teaching and learning (Mavuru & Ramnarain, 2020). Moreover, Lemke (2001) agrees by stating that the learning of science should be viewed as a human activity which is situated in larger communities and culture while it can be extended beyond the classroom. Meanwhile, Stears et al. (2003) assert that individually constructed knowledge is socially mediated as a result of cultural experiences.

It is acknowledged, however, that this theory focuses mainly on children. Notwithstanding, Eun (2008) points out that learning and development do not occur in children only but occur in adults (including teachers) as well. The teaching and learning takes place in a social set up where teachers and learners learn together. In light of this, the theory is deemed useful in my study as it explains how learning takes place in the classroom which is based on socio-cultural contexts (Mavuru & Ramnarain, 2020). Therefore, the theory will be used to unpack the social

interactions that happened in the classroom between teachers and learners. From this theory, three concepts were used, namely, *mediation of learning*, *social-interactions* and *zone of proximal development* (ZPD).

Mediation of learning

The concept mediation of learning is attributed mainly to two psychologists, Vygotsky (1978) and Feuerstein (1991). These psychologists were interested in how social interactions influence learning (Presseisen & Kozulin, 1992). Vygotsky (1978) describes mediation as learning sharpened by significant people in learners' lives while Presseisen and Kozulin (1992) explain mediation of learning as the starting point of social interactions between the teacher and the learner in the learning process. Similarly, Ramasike (2016) defines mediation of learning as a technique or skill incorporated in the learning process to acquire knowledge. Ramasike (2016) further adds that it is a learner centred skill which is in support of social interactions. Put differently, learners are central in the learning process.

Vygotsky (1978) further articulates that mediation of learning in which an adult or more capable peers interact with one another and their environment enables improved mental developments. Extending on Vygotsky's seminal work, Presseisen and Kozulin (1992) also point out that mediation of learning connects the teachers and learner in constructing new knowledge. They further state that it is the product of the interactions between the teachers or peers who are capable and those learners who are less capable in a social setting. Vygotsky (1978) further argues that mediation of learning can also be achieved through symbolic tools, language, or behaviour of another human being.

In line with the research study, mediation of learning was used because it incorporates social interactions and emphasis should be on symbolic tools and language. Teachers should create environments which accommodate all learners from diverse socio-cultural backgrounds (Mavuru & Ramnarain, 2020) for better understanding of the topic of chemical changes. The symbolic tools should enable learners to establish what is to be taught and what is intended to be achieved. Additionally, language is considered to be the most extensive tool in mediation. Moreover, Gibbons (2003) explains that language learning is a socially mediated process in which teachers and learners are active participants in language co-construction. As a result, teachers and learners use language to create meaning and make sense of concepts. Meanwhile, Shabani (2016) also

notes that "social mediation with dialogic negotiation triggers higher forms of human's mental functioning" (p. 3). The mediation of learning takes place through social interactions.

Social interactions

Vygotsky (1978) describes social interactions as learning taking place with others who are more knowledgeable such as parents, teachers, and peers. He refers to these people as More Knowledgeable Others (MKO). These social interactions can be different from one social group to another and people can interact with one another to share experiences and expectations. According to Vygotsky, social interactions can result in development. He argues that development in a child appears first in a social set-up and the psychological term is regarded as internalisation. Concurring, Rubtsov (2016) adds that social interaction is a mechanism of distributing functions which includes some methods of mastering those functions. Rubtsov (2016) further adds that it is through social interactions that what was not developed could be developed through proper guidance. A classroom is regarded as a social set up and the social interactions which might take place between teachers and learners and within learners themselves will play an important role in this study. Through classroom observations and videotaped lessons, I was able to determine the creation of social interactions during teaching and learning. The social interactions taking place in the classrooms might result in the shifts of the ZPD of learners.

Zone of Proximal Development (ZPD)

Vygotsky (1978) explains ZPD as the difference between what a child can do independently and what a child can do with help from MKOs. Concurring with Vygotsky, Lui (2012) defines the ZPD as the difference in what a child can do on their own and the potential which children have to achieve while engaged with others. Meanwhile, Thompson (2013) articulates that the most powerful form of learning takes place when learners are working within their ZPD. In order for the ZPD to be reached, valuable contributions should be made during teaching and learning. Furthermore, Stott (2016) points out that no ZPD takes place before a learning activity. Instead, the ZPD is created through and during social interactions. The ZPD is considered to be the area where learning is situated in the topic of chemical changes.

Goos (2004) identifies aspects of ZPD as *scaffolding*. Scaffolding is described by Brunner, Scharaw, Norby, and Ronning (2004) as a teaching strategy which assists learners to perform activities that they are unable to do on their own but can do through guidance without being

given the answers. Through scaffolding, learners might be able to discover new information by themselves. Meaningful interaction should occur between teachers and learners when doing activities. The learners' ZPD and teacher's ZPD might expand during interactions. Concurring, Shabani (2016) accentuates that learning is a process and the developmental changes in children can also occur in professional development of teachers. They might improve the practice of how children interpret situations. During the teaching and learning of the topic of chemical change, teachers provide scaffolding to learners in order to mediate learning. Vygotsky (1978) proposes that learning needs to move from what is known to the unknown for the child to move from what they are capable of achieving alone towards what they can do with a MKO. The key concepts are summarised below in a table form adapted from Eun (2008, p. 14). The concepts are related to the teaching and learning of science lessons which will take place in the classroom.

Table 2.1: The theoretical key concepts related to the research study (adapted from Eun, 2008, p. 144)

Concepts	**Related to the research study practices**
Mediation	This is how teachers use different methods of teaching, strategies used in their classrooms during the observed lessons and resources or materials used to teach the topic of chemical changes.
Zone of Proximal Development	This is how teachers used the teaching methods and teaching strategies in mediating learning and development of knowledge when learners were engaged in activities that took place within their ZPD.
Social interaction	The collaborations taking place in the classroom. Meaning that, the ways in which teachers used the mediation processes to promote and encourage social interactions amongst their learners and themselves and for learning to take place.

Since the focus of the study is on teachers, they had to possess the type of knowledge known as pedagogical content knowledge which is the analytical tool of this study.

2.8.2 Analytical framework: Pedagogical content knowledge (PCK)

Teachers should possess certain knowledge for them to teach effectively. This kind of knowledge is identified by Shulman (1986; 1987) as pedagogical content knowledge (PCK). Drawing from Geddis, Onslow, Beynon and Oesch (1993), teachers draw from PCK of what they are about to teach, in particular ways. They added another aspect that PCK must be Content Specific Pedagogical Knowledge. They should possess knowledge of the content to be taught to the learners. Furthermore, PCK assists teachers in learning about the nature of teaching methods to apply (Mavhunga, Ibrahim, Qhobela & Rollnick, 2016). Shulman (1986) further proposes seven categories of knowledge for the teacher that is, subject matter knowledge (SMK), pedagogical content knowledge (PCK), curriculum knowledge, knowledge of learners and their characteristics, general pedagogy, educational contexts, and educational purposes. Subject matter knowledge refers to the understanding of the discipline in which the teacher teaches (Van Driel & Berry, 2012). In order for the teacher to develop a good PCK, they should have a strong foundation of SMK. SMK shows the amount of knowledge a teacher has in a specific subject. On curriculum knowledge, a teacher needs to have a comprehensive knowledge of the curriculum in use and its expectations in order to enhance PCK. He further identifies learners' characteristics as significant so as to be able to understand the type of learners in the learning environment. These learners might come from different backgrounds, cultures, use different languages and learning styles. Teachers have to plan according to the learners' needs for them to understand science content. Moreover, Kind (2009) supports that the mediating factors such as presentation of the content, goals, and students' context should be taken into consideration. That is, the approaches which are applied in the classroom, individual differences, cultural background, and the interactions, have an influence on the teachers' PCK.

Furthermore, Shulman (1986) suggests that mediation of learning involves the transformation and presentation of SMK so as to make it comprehensible and easily accessible to learners. Transformation involves preparation, presentation, instructions to be given, and adaptation. Teachers are required to prepare lessons and select suitable supporting materials in order to mediate learning of science lessons effectively. That is, the topic of chemical change which is the focus of this study is not an exception. This explains that PCK is a teaching theory that focuses on teachers' knowledge and how they create and transform that knowledge to be easily accessible to the learners.

The strategies which teachers used in mediating learning of the topic of chemical change in this study are part of PCK. Kind (2009) critiques Shulman's theory, stating that it is not backed up by enough theoretical evidence to support the existence of PCK. PCK is a distinct category in a teachers' knowledge base. However, Shulman acknowledges that PCK is difficult to isolate and measure because it is personal and develops with experience. Shulman further states that the way teachers transform this content knowledge for teaching shows commonalities.

PCK links the strategies and content which the teachers possess for effective teaching and learning. PCK emphasises the manner in which teachers know what they teach about and how they teach. Notwithstanding, different topics will have different approaches and Mavhunga and Rollnick (2013) term these different approaches as topic specific pedagogical content knowledge (TSPCK). Mavhunga and Rollnick (2013) argue that teachers normally develop unique knowledge for a certain topic considering the aspects of the content to be covered. They consider five components of TSPCK, namely, learners' prior knowledge, curricular saliency, what is difficult to teach, representations including analogies, and conceptual teaching strategies (Mavhunga & Rollnick, 2013) (see Figure 2.3 below).

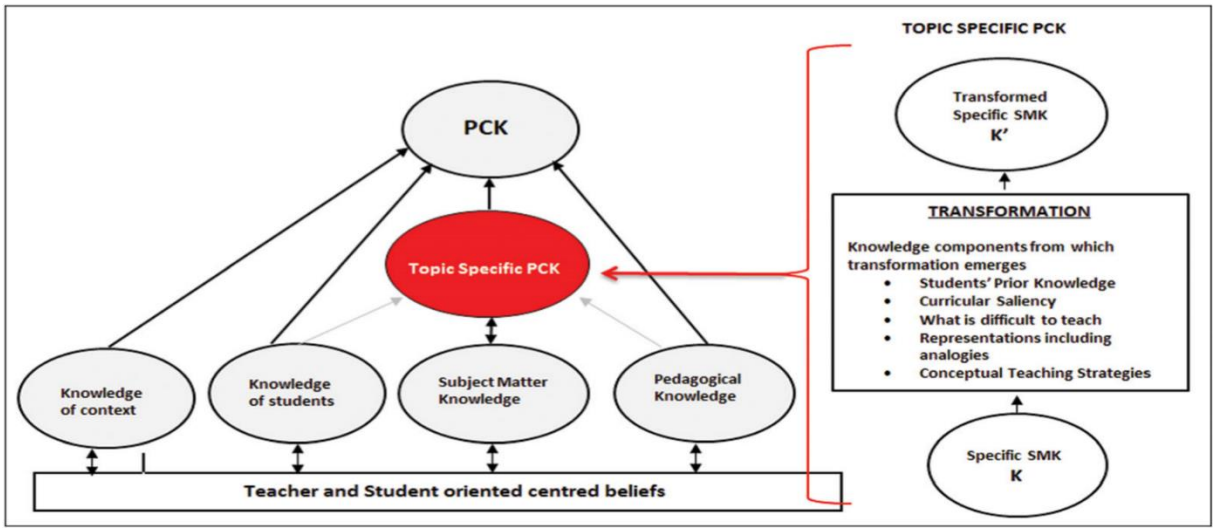

Figure 2.3: A model of Topic-Specific PCK (Mavhunga & Rollnick, 2013, p. 115)

By locating PCK at a specific topic, Mavhunga and Rollnick (2013) argue that PCK has a specific nature. Drawing from Geddis and Wood's (1997) seminal work, Mavhunga and Rollnick (2013) stipulate that teachers need to develop the awareness that teaching requires the transformation of their SMK. They require specific consideration to be made about SMK (Mavhunga & Rollnick,

2017). Five components are crucial to teaching and learning and should be explained with an understanding of the knowledge needed for the content knowledge (CK) transformation in a particular topic.

The model of TSPCK in this study was used as an analytical tool to look at how teachers mediate learning on the topic of chemical changes. That is, learners' prior knowledge, how teachers acknowledge what learners bring to their classrooms and how they clear up misconceptions. The prior knowledge could be in the form of IK. Teaching of the topic of chemical changes explores some of the IK related teaching practices. This is one-way science might be contextualised. For example, Kakambi (2020) explored the mobilising of the indigenous practice of dyeing and weaving African baskets as a catalyst to mediate learning of chemical and physical changes while Nikodemus (2017) used *Oshikundu* to mediate learning on rates of reactions associated with fermentation. Findings from these studies reveal that scientific concepts were developed resulting in greater conceptual learning and sense-making.

In my study, teachers and learners came from diverse socio-cultural backgrounds. That is why Vygotsky (1978) socio-cultural is appropriate for this study. During teaching and learning, teachers and learners were in a learning environment where they came together, interacted with each other, and shared knowledge regarding the topic of chemical changes. In addition, the five components play a major in teaching and learning. Thus, curricular saliency, or sequencing of the curriculum, requires teachers to identify main ideas and concepts of the topic. What is difficult to teach focuses on how teachers dealt with difficult concepts within the topic. Interpretations and analogies have to do with how teachers made their lessons' content easily accessible to the learners. The last component of conceptual teaching strategies include the approaches used to teach the main concepts and content of the topic.

2.9 Chapter Summary

The main aim of this chapter was to discuss literature which informs the study. I discussed the literature in relation to the topic of chemical changes, prior knowledge, and indigenous knowledge. What emerged from literature is that teachers should consider the integration of prior knowledge and indigenous knowledge for learners to make some links between science in the classroom and at home. Teachers should possess appropriate PCK in order to teach effectively. Moreover, I discussed the role of practical activities in science education together with the

interrogation on challenges associated with it. Literature points out that practical activities are of great importance as learners can observe and manipulate objects for better understanding of science topics. Lastly, I discussed the theoretical framework which informed my study which is Vygotsky's socio-cultural theory and its concepts. The analytical framework is from Shulman's (1986; 1987) theory of pedagogical content knowledge with the focus on TSPCK form Mavhunga and Rollnick (2013).

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

The aim of this study was to explore how grade 9 Physical Science teachers mediate learning of the topic of chemical changes. To achieve this goal and generate data, I needed to use suitable approaches. In this chapter, I thus provide the research methodology which I used. The chapter starts with the research paradigm, which is the interpretive paradigm, research design, which is a case study, the research site, sampling, and researcher's positionality are explained in detail. This is then followed by data gathering techniques and the research process. Thereafter, a narrative of data analysis has been provided. Finally, I discuss the ethical and validity issues which were taken into consideration.

3.2 Research Paradigm

This study is located within the interpretive paradigm. An interpretive paradigm is defined by Cohen, Manion, and Morrison (2011) as a way of understanding human meanings and their behaviour without intervening in the process. Concurring, Hammersley (2013) articulates that in this paradigm, multiple interpretations can be developed about human relations and the researcher should try to understand these paradigms in order to try and avoid bias in studying these events and humans in a natural setting. Paradigms interpret how researchers view the world and what is acceptable in doing research including how it should be done (Bertram & Christiansen, 2015). In addition, the interpretive paradigm views reality and meaning as socially constructed, where people make sense of their social realities (Cohen, Manion, & Morrison, 2018). In this paradigm, researchers look at objects, humans, and events in order to understand their social contexts (Pham, 2018). Moreover, this study was conducted in a natural setting in order to provide authentic data related to the objective of the research.

However, even though researchers tend to gain a deeper understanding of the phenomenon and its complexity in its unique context, the study should not try to generalise the base of

understanding for the whole population (Creswell, 2014). Thus, the data generated might be impacted by personal viewpoints and values.

The purpose of this study was to gain insight on perspectives and experiences on how teachers mediate learning of the topic of chemical changes. The observations which were made in the learning environment enabled me to make some interpretations. I aimed to develop a greater understanding of how people make sense of the context in which they live and what makes sense to them (Cohen et al., 2018). The interpretive paradigm was found to be appropriate for this study as the basic assumption guiding this paradigm is to understand the meaning of what informs behaviour. Data gathering techniques such as observations and interviews which were adopted in this study are associated with the interpretive paradigm. Interviews and lesson observations were conducted in the research process so that the behaviour of participants during teaching and learning could be observed.

3.3 Research Design

Bertram and Christiansen (2015) explain research design as a plan of how the researcher systematically collects and analyses data that is needed to answer research questions. In concurrence, Cohen et al. (2018, p. 175) state that research design is the "evidence needed to address the research purpose, objectives and questions, the logic that underpins the connections between purpose, objectives, data and conclusions drawn". That is, there are certain criteria that a research design should meet with the use of appropriate methods that the researcher should employ in order to collect the expected data. Within the interpretive paradigm this study adopted a case study research design.

3.3.1 Case study

This study is a qualitative case study. A qualitative study aims to discover and understand the situation of people's views (Merriam, 2009). Furthermore, Creswell (2014) stipulates that a case study is an in-depth explanation of systematic explanations such as an activity, process, event, or it focuses on extensive data collection on an individual. Thus, the researcher should be clear on the research focus, objectives, and the extent of the research. Moreover, case studies look at what a particular situation is like so that they are generally descriptive in nature (Bertram & Christiansen, 2015).

To Cohen et al. (2018), case studies are specific and are frequently designed to illustrate more general principles. That is, the case study analyses a phenomenon from the perspective of the participants. The actions of the participants and their corresponding feelings and thoughts are emphasised. I used a case study because the study was interested in exploring how grade Physical Science teachers mediate learning of the topic chemical changes. In light of this, Cohen et al. (2018) express that a case study is specific and can be used as an instrument to explore a more general issue. Even though a case study does not seek to make generalisations and lacks representativeness, Merriam (2009) posits that it captures lived experiences and can possibly answer research questions.

3.3.2 Research site and sampling

The study was conducted in the Otjozondjupa region, which is the largest region among the 14 regions in Namibia. It is located close to the centre of the country (see Figure 3.1 below). The Otjozondjupa region is where the schools were located and where the study was carried out.

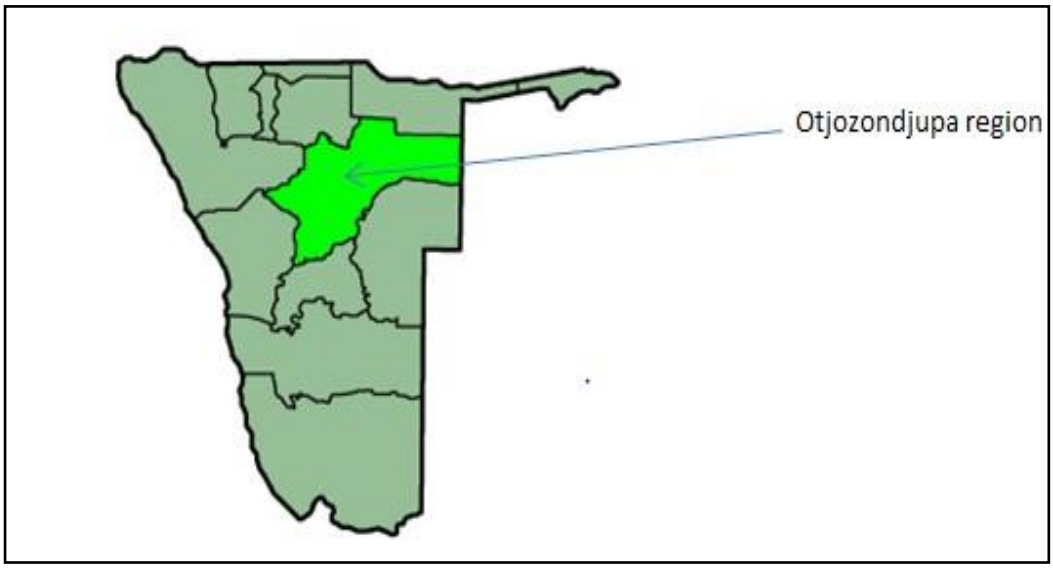

Figure 3.1: Geographical map of Namibia with Otjozondjupa region marked in green

The two schools in the Otjozondjupa region were coded as school one and school two. Both schools are regarded as rural schools. School one is 100 km from the nearest town and school two is 110 km away from the nearest town. Both schools are boarding schools with water and electricity and have grades from pre-primary to grade 9. They both have functional school

buildings, computer labs, Wi-Fi, and science laboratories which do not have science equipment and chemicals to carry out practical activities.

Around these schools, there are tarmac roads, facilities such as clinics, police stations, Namibian Post Offices, mini-fuel stations, and other mini government offices. School one is 80 km south-west of the school where I am currently working and school two is 40 km east from my school. School one has a total number of 534 learners that is, 292 girls and 242 boys. School two has 585 learners, 301 girls and 284 boys. The teacher to learner ratio for school one is 1: 35 and school two is 1: 39. These schools were closed in March 2020 due to the outbreak of Coronavirus (COVID-19) in Namibia. Upon re-opening of these schools in July 2020, the school were cleaned, sanitised, fumigated. Wearing of masks was compulsory for teachers and learners, sanitising hands and keeping 1m social distance.

Both schools have one principal and three heads of department for junior primary, language department, and mathematics and science department, respectively. In addition to that, the schools have management structures such as the school board, learners' representative council, class monitors, and parents' committee. Since these schools are close to mine, it was easy to access them. The schools preform along the median. The participants in this study were grade 9 Physical Science teachers and both of them were new appointees as Heads of Department (HOD) for mathematics and science. These two teachers have been teaching mathematics and physical science for more than eight years and they were purposively sampled or selected based on this. These teachers have more experience in teaching than in heading a department. Both teachers have experience of teaching in township schools and semi-rural schools. At the time of this study, these teachers were in schools catagorised as rural schools. The summary of the teachers' profiles is presented below.

Table 3.1: Teachers' profiles

Position	Teachers' codes	Gender	Qualification	Teaching subjects	Teaching grades	Teaching experience (Years)
Teacher (Head of Department, Math and Science)	Teacher 1: T1SSI (semi-structured interviews) T1LOB (lesson observations)	Male	-Basic Education Teacher Diploma (BETD) -Advanced Certificate in Education (ACE)	Physical Science	8-10	17
Teacher (Head of Department, Math and Science)	Teacher 2: T2SSI (semi-structured interviews) T2LOB (lesson observations)	Male	-Basic Education Teacher Diploma (BETD) -Advanced Certificate in Education (ACE)	Physical Science Maths	8-10 5-7	13

Purposive sampling was used to select these teachers. Sampling refers to a technique used to select a small group with a notion to determine the characteristics of a large group (Brynard, Hanekom, & Brynard, 2014). In this study, I essentially used purposive sampling as I made a particular choice of people who were the participants. Furthermore, Creswell (2014) explains purposive sampling as sampling that involves the researcher making specific choices about which people, groups, or objects should be included in the sample. In addition, Cohen et al. (2018) concur with Bertram and Christiansen (2015) that purposive sampling is a method in which the researcher chooses a specific sample for a particular purpose. Thus, the research site and participants were selected for a specific purpose.

These teachers showed interest during a science workshop when I was explaining that I would carry out this study. I spoke in-depth with these teachers in order to have a deeper understanding of the situation and a balanced, non-judgmental view. The potential benefit of selecting 2 teachers was to generate data and focus in-depth about their experiences, views and pedagogical insights towards mediating learning of the topic of chemical changes. In addition, grade 9

teachers were chosen because grade 9 is the first exit grade to write national examinations in Namibian schools in order to qualify for grade 10. Grade 10 is the first senior secondary phase up to grade 12.

3.3.3 Researcher positionality

Thomas (2013) expresses that an interpretive researcher has an undeniable position in the research process and the position of the person affects the nature of observations and interpretations that they make. Moreover, positionality includes the multiple identities of both researchers and participants which can impact the research process (Bourke, 2014). Thus, due to the fact that I am a master's student at Rhodes University, who has been teaching Physical Science for 11 years and been recognised as one of the top performing teachers in the region at grade 10 level, I was aware of the power relations that could play a role during my research process in this study. For instance, my position was presented as a teacher like them, coming in as people from the same profession, and explaining that I was also learning from them. I explained the motive for carrying out the study and explained how the findings might help us better understand the difficulty of the topic. I regarded them as experienced teachers in the field of science as both of them were appointed to head the math and science departments. The study might improve the mediation of learning of the topic chemical changes.

3.3.4 Data gathering methods

Data gathering methods are "ways of planning, structuring and execution of the research in order to comply with the demands of truth, objectivity and validity" (Brynard et al., 2014, p. 38). In this study, I used semi-structured interviews, lesson observations, stimulated-recall interviews, and teachers' reflections to generate data. I now discuss each of these below.

3.3.4.1 Semi-structured interviews

In this study, semi-structured interviews were used. Essentially, an interview is an interaction in which a person obtains information from another (Gay, Mills, & Airasian, 2009). According to Cohen et al. (2011), a semi-structured interview is a flexible approach in generating data where questions are prepared and asked. What makes semi-structured interviews useful is that a researcher is able to ask probing and follow-up questions for clarification (see Appendix F).

Questions were prepared as a guide and were piloted by a colleague. An interview guide is a set of questions which the interviewer intends to ask (Leedy & Ormrod, 2014).

In this study, I conducted these interviews with two Physical Science teachers and they were voice recorded with their permission. The aim of these interviews was to find out the teachers' perspectives, experiences, and pedagogical insights in teaching and learning of the topic of chemical changes. These interviews enabled participants to express themselves and helped me to gain in-depth data from a small sample size. The interviews also surfaced some issues around the topic of chemical changes.

The interview session was supposed to take approximately 15-20 minutes for each teacher but instead it took each participant approximately 25-30 minutes as they were eager to give more detailed information regarding the topic. We followed the protocols of COVID-19 in which we sanitised hands, wore masks, and kept 1m social distance during interviews. The semi-structured interviews were an opportunity for them to have their opinions heard. Cohen et al. (2018) explain that semi-structured interviews enable participants to discuss their interpretations of the world where they live and express how they regard situations from their point of view. Semi-structured interviews allowed me to gather in-depth data which was face-to-face. I could probe for more information and clarify unclear questions from their responses.

The interviews were audio taped with the permission of the participants and thereafter, they were transcribed verbatim for clarity (see Appendices G and H). I also gave the transcripts back to the teachers for member checking. Member checking is when collected data is returned to the participants so that they can check for accuracy and errors made (Cohen et al., 2018). The main advantage of audio recording is that the recordings can provide a detailed account of an interview which can be replayed (Davies, 2007). Participants showed interest in verifying what they had answered. The audio provided detail and made transcription easier as the audio recordings could be replayed several times.

3.3.4.2 Lesson observations

Observations allows a researcher to watch certain details, as Rule and John (2011) allude, that data can be gathered by watching behaviour, events, and noting physical characters in a natural setting. It is through observations that one gathers open-ended first-hand information on a specific issue (Creswell, 2012). Concurring, Bertram and Christiansen (2015) accentuate that

observation occurs when the researcher goes to the site and observes what happens to get first-hand information. Thus, observation provided information on what was really happening in the classrooms during mediation.

In light of the foregoing discussions, Cohen et al. (2018) posit that observations offer the investigator an opportunity to gather lived data from naturally occurring social situations. In this study, I used observation to gain more insights on the teachers' practices, the interactions taking place in the classroom between the teacher and the learners, and the learning environment (Vygotsky, 1978). The teachers gave me an opportunity to look at their teaching pedagogies, the use of resources, and the interpretation of specific competencies from the Physical Science syllabus for grade 9.

Lesson observations were delayed due to the Coronavirus pandemic (COVID-19). Upon re-opening of schools, classrooms were firstly fumigated, and arranged in such a way that health protocols of COVID- 19 were followed. Learners were divided into smaller groups, 1m apart and wearing of masks. Continual sanitising of hands and taking temperatures every day was the norm. During COVID-19, some learners stayed at home and did online learning or collected study materials from schools. Learners who were vulnerable and marginalised were negatively affected by this new normal which was introduced during the lockdown period (Nunes, 2020).

As espoused in Vygotsky's socio-cultural theory, the observations helped me to find out about the social interactions in the classroom. The lessons were videotaped and photos were taken with the permission from the participants (see Appendices D and E). In light of this, after observations I had discussions with each of the teachers to reflect on their lessons and how they felt about the research process. Moreover, Zaare (2013) indicates that classroom observations serve as a guide for teachers to reflect on their own teaching practice and learn from one another to improve their teaching practice. Observations were complemented by reflections which allowed me to understand the context, see things clearly, and understand what might have been missed in the interviews. Stimulated recall interviews were also done to reflect on their lessons and validate the data.

3.3.4.3 Stimulated-recall interviews

Stimulated recall-interviews (STI) are video-recordings that are replayed to the participants to recall their thinking during events (Lyle, 2003). Furthermore, Fox-Turnball (2009) adds that

stimulated recall-interviews are a method which allows participants to recall their thinking based on the practice of the lesson by a video. These stimulated recall interviews lasted for almost 25-30 minutes as teachers were delighted to see themselves in video recorded lessons. COVID-19 protocols were observed. I watched the video recordings with each teacher after the lessons and they commented on how they mediated their lessons (see Appendix M). During this time, I asked questions on areas which needed clarification. I wrote some notes and comments made by teachers based on the lesson. By doing this, the notes agree with Cohen et al. (2011) who suggest that a video recording of a lesson should be played to the participants for them to refresh their thinking and clarify ideas. The notes provided me with more insight from teachers' practices, seeking to identify evidence to answer the research questions. The notes also played a role as a deeper reflective process. Participants could reflect on their lessons in order to strengthen their understanding on the topic and alternatively change their ways of teaching.

3.3.4.4 Teachers' reflections

Eun (2008) explains that reflections are self-analysis practices which lead to understanding and are personal. Moreover, Macmillan and Schumacher (2014) add that reflections are personal accounts of the learning experience. Personal reflection is a way of allowing teachers to express their feelings and views about their teaching experience so that they are able to make suggestions. Concurring, Killen (2015) explains that the use of reflections is an effective way of helping to consolidate one's learning to identify gaps in developing understanding of others. Similarly, Göker (2016) stipulates that reflections are considered as important tools in teachers' development as they create self-awareness, evaluation of teaching methods used, problems encountered in teaching, and changes in teaching practice needed where necessary.

As I had learnt this strategy from Rhodes University, at the beginning of the year the initial plan was for the participants to have a journal book where they would write reflections about their experiences after teaching the lessons. This strategy was not achieved as schools were closed for a significant period of time due to COVID-19. Upon lesson observations, reflections were done through watching videotaped lessons and some follow-up questions. Thus, the data gathering technique explored how follow-up questions enabled or constrained their mediation of learning on the topic of chemical changes. Participants reflected on the research process, teaching and learning, and what to do differently the next time. The following table summarises the research questions and data gathering techniques.

Table 3.2: A summary of research questions and data gathering techniques

Research question	Methods	Purpose of the Question
What are grade 9 Physical Science teachers' views, experiences and pedagogical insights regarding mediating of learning of the topic of chemical changes?	Semi-structured interviews	To find out teachers' experiences and pedagogical insights of the topic of chemical changes.
How do grade 9 Physical Science teachers mediate learning of the topic of chemical changes?	Lesson observations and stimulated recall interviews	To investigate actual teaching taking place in the classroom and teacher learner interactions.
What lessons appear from teachers' reflections after mediation of learning of the topic of chemical changes?	Teacher's reflections	To find out what teachers learnt from teaching and learning of the topic of chemical changes.

3.3.5 Research goal and research process

The main goal of this study was to explore how grade 9 Physical Science teachers mediate learning of the topic of chemical changes.

3.3.5.1 Research process

These are steps which were followed to generate data to answer the research questions. In this study there were four phases which are explained below.

Phase 1: In this phase, I analysed documents such as the National Curriculum, the physical science syllabus for grade 9, the examiner's reports, two textbooks for physical science, and previous questions papers for grade 9. These documents were consulted to find out what is the requirement on mediating the topic of chemical changes. The examiner's reports normally provide detailed information of general problems acquired by learners and suggestions for teaching resources to be used. Data from these documents was base line data which was used to strengthen the context of the study.

Phase 2: The semi-structured interviews were conducted with two Physical Science teachers in order to find out their perspectives, experiences, and pedagogical insights towards mediating learning of the topic of chemical changes. They were conducted with these two Physical Science

teachers individually. These interviews allowed me to probe the participants in order to get more insight and understand their opinions. Furthermore, the interviews helped me to find out how much they value the topic of chemical changes and how they mediate the topic, that is, to ascertain their pedagogical insights. This helped me to answer the research question 1 of the study.

Phase 3: Lesson observations were done in this phase and were concerned about gaining some insights on their teaching practices. I observed three lessons by each participant and each lesson took approximately 35 minutes. During observations, I was able to see how teachers presented their lessons starting from the introduction, lesson presentation, learner's prior knowledge, resources used, how learners were engaged in the activities, and the conclusion of the lessons. I gathered data on teachers while in the classroom. This determined the actual teaching which took place in the classroom. Lessons were videotaped by a colleague from those schools while I was writing down notes.

Phase 4: Stimulated recall interviews and reflections were done in this phase. The video-taped lessons (see Appendices K and L) were played to the participants to stimulate reflections and discussions. Additionally, this was done for member checking purposes and to clarify issues for the purpose of validation. This provided me with more insights on the outcome of observations. It also provided an in-depth understanding of teachers' practices including the way they mediate learning, their understanding, and interpretation of the concepts. The reflections were taped and transcribed regarding how the mediation process took place (see Appendix M).

3.3.6 Data analysis

Data analysis involves organising, noting patterns, themes, and categories (Cohen et al., 2011). Qualitative data analysis aims at deriving meaning from data by placing it into themes and categories. The researcher has to immerse themselves in the data in order to make sense of it. During the process, emerging patterns were noted and recorded. In this study, a thematic approach to data analysis was used in order to identify categories, patterns, and themes. The thematic approach is flexible when identifying themes (Braun & Clarke, 2006). That is, the data in this research was coded with themes, as Cohen et al. (2018) points out that data analysis is used to reduce data by selecting important features based on the research focus. Coding is the process of classifying data according to a particular theoretical outline (Babbie & Mouton, 2005). Similarly, Creswell (2012, p. 243) posits that coding is "segmenting and labelling data". Through

coding, the researcher is helped to classify similar information. The figure below indicates how data was analysed to come up with themes.

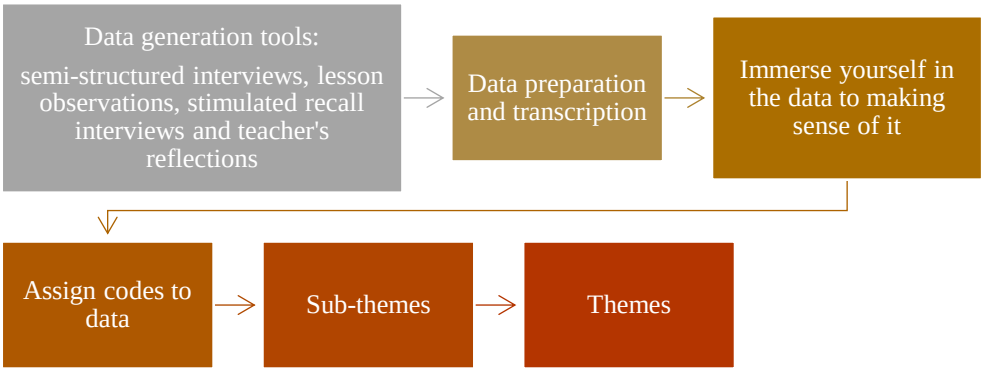

Figure 3.2: Data gathering and analysis

To begin with, data was generated through semi-structured interviews, lesson observations, stimulated recall interviews, and teachers' reflections (see Appendices K, L, and M). The research questions were used to guide the process of grouping the collected data into themes. I transcribed the data from semi-structured interviews. Transcription is a practice of converting audio tape recording into text (Creswell, 2012). I immersed myself in the data and the process of analysing data started as narratives which were written out like stories. The narrative stories helped me to make sense of the data (Sedlacek & Sedova, 2017). Similarly to Nhase (2019), these narrative, episodes were identified and coded. Within these episodes, themes and categories were identified. The sub-themes which emerged were then grouped as themes.

During the interpretation of data, I used two theories, namely, socio-cultural theory and pedagogical content knowledge (see Section 2.3). I used socio-cultural theory focusing on the following concepts, *mediation of learning*, *Zone of Proximal Development* and *socio-interactions* (see Sections 2.31 and 2.3.2). This theory was used as a learning theory and it was used to unpack the social interactions which took place during teaching and learning. Within the concepts, I used indicators from Atallah, Bryant, and Dada (2010) during data collection and analysis. I looked at how teachers engaged the learners in activities together with the acknowledgement of learners' differences by the teacher. Moreover, I looked at whether a shift in understanding took place within the ZPD for the learners and how teachers made the concepts of the topic easily accessible to the learners. Below is a table which shows Atallah et al.'s (2010) indicators which were used to analyse data for research question 1.

Table 3.3: Conceptions, experiences and attitudes (Atallah et al., 2010, pp. 3-4)

Concept	Indicator	Research question	Research instrument
Perspectives	*-Describing the topic of chemical changes.* *-Describing the purpose of the topic of chemical changes.* *-Describing what is required to understand the topic of chemical changes.* *-Describing what will be used to understand the topic.* *-Describing the relevance of the topic to world views.* *-Describing what type of resources will be used to teach the topic of chemical changes.*	1	Semi-structured interviews
Experiences /attitudes	*-Describing thoughts about the topic of chemical changes.* *-Describing attitudes towards the topic of chemical changes.* *-Describing expectations when teaching the topic of chemical changes.* *-Describing the ability and approaches used to teach chemical changes.* *-Describing what is being used towards understanding the topic and* *-Describing what is believed indicates the attainment of specific competencies.*	1	Semi-structured interviews

Data from semi-structured interviews were analysed to understand teachers' experiences, views, and pedagogical insights regarding the topic of chemical changes. Data from lesson observations, stimulated recall interviews, and teachers' reflections were analysed to understand the events that took place during teaching and learning in the classrooms. The analytical tool for data analysis was TSPCK from Mavhunga and Rollnick (2013). The TSPCK was used in order to

understand the participants' understanding of the topic of chemical changes. These include learners' prior knowledge, curricular saliency, what is difficult to teach, representations, and conceptual teaching strategies. The data was analysed on how teachers interacted with their learners drawing from their prior knowledge and knowledge of curricular saliency. It was also important to understand how participants used their conceptual understanding, representations, and teachings strategies. I looked at episodes where TSPCK was featured on teachers' knowledge and practice.

3.3.7 Validation, trustworthiness and reliability

According to Maxwell (2008), validity is the key issue in the debate about legitimacy of qualitative research. It is significant for a successful and effective research (Cohen et al., 2011). These scholars further posit that if the research is invalid, then it is worthless. The researcher needs to make sure that data gathering tools are systematic, credible, and transparent (Bertram & Christiansen, 2015). Thus, to validate the data, a method of triangulation was employed in this study including member checking (Cohen et al., 2018). That is, I used a variety of data collection techniques such as semi-structured interviews, lesson observation, stimulated-recall interviews and teacher's reflections for the purpose of triangulation. Cohen et al. (2011, p. 195) define triangulation "as the use of two or more methods of data collection in the study of some aspects of human behaviour". They further articulate that triangulation is a powerful method to ensure validity, particularly in a qualitative research. Similarly, Gay et al. (2009) refer to triangulation as "the degree which qualitative data accurately gauge what you are trying to measure" (p. 375). During data analysis, transcriptions were done and then given to the participants for them to check for accuracy.

Moreover, stimulated recall interviews which were used and member checking played a role in validating the data. These research methods differ, and as Cohen et al. (2018) indicate, the weakness of one method will be compensated by the strengths of the other. They further assert that knowing if one has achieved an acceptable level of validity, assures an important key to effective research. Moreover, Macmillan and Schumacher (2014) describe validity as having mutual meanings on interpretations and concepts between the participants and the researcher. Thus, the transcripts were given back for member checking known as "respondent validation" (Merriam, 2009, p. 27). The aim of doing this is for accuracy on recorded information. Further, a critical friend was also used in the verification of interview scripts. In addition to that, video

recordings were watched with the two Physical Science teachers individually for clarification and to make corrections.

3.3.8 Ethical considerations

In carrying out this research study, there were some ethical issues which I needed to adhere to. In this section, I discuss various aspects of ethical principles which are the requirements from Rhodes University which have to be satisfactory and approved by the Higher Degrees Committees for the university (see Appendix A). These are discussed below.

3.3.8.1 Respect and dignity

When carrying out a research study, participants must be respected. They are not subjects, nor objects in the research (Cohen et al., 2011). In this study, the participants' rights were respected and their welfare. Furthermore, their anonymity and privacy were protected. Since my school is in the same cluster with these schools, we are used to meeting to discuss educational matters. I visited my participants at their schools and discussed the following: the nature and purpose of the study, the programme of the study, the interviews, observations, video recordings, and possible benefits of the study. I informed them of the consent letters and on top of that I informed them that the study was voluntary and that they could withdraw at any time. Participants were also informed that their schedules would not be disturbed and I only visited them based on their availability. During data presentation, participants were also made aware that their real names would not be published and they agreed to be addressed as teacher 1 and teacher 2.

3.3.8.2 Transparency and honesty

Data could not be collected without the permission from the director (see Appendix B). Thus, I requested permission from the regional director, thereafter the circuit inspector, and the school principals (see Appendix C). Moreover, consent letters were written to the participants explaining the aim of the study, benefits, and voluntary participation (see Appendices D and E). As Creswell (2008) explains, consent forms for the participants should include voluntary participation, that their identity would be protected, and that it would not put them in danger.

3.3.8.3 Accountability and responsibility

In this study, the participants were teachers and both of them were heads of department for mathematics and science. I was aware of the power relations which could interfere with the study. That is, I discussed issues of power with the participants. I kept my position as a teacher so that I would not misuse my position as a researcher. I had to make sure that I created a friendly communicative environment where participants were treated equally regardless of their cultural, political, educational, and religious background. I kept communicating with the participants regularly for effective running of the research study even during the COVID-19 lockdown.

3.3.8.4 Integrity and academic professionalism

The study is my own work and where others' work is used, I acknowledged and adhered to the referencing standards throughout this research study. Data were generated with instruments of high reliability, helping to avoid misreporting or manipulation (see Appendices F-M).

3.4 Chapter Summary

In summary, this chapter presented the scope of the study as a qualitative case study, which was situated within the interpretive paradigm. Furthermore, in this chapter, I outlined the data gathering techniques followed by the research goal, research questions, and research process. Thereafter, I discussed how data were analysed. The issues of validity and trustworthiness were discussed to make sure that as a researcher, myself and participants understood the research process. Ethical considerations were also discussed and transparency was key throughout the whole process.

CHAPTER FOUR: SEMI-STRUCTURED INTERVIEWS AND LESSON OBSERVATIONS

4.1 Introduction

Two teachers were interviewed and voice recorded with their permission. The interviews were done on different days based on participants' timetable for teaching and learning. The interviews started with the greeting, thereafter, a discussion about how COVID-19 impacted teaching and learning. The protocols for COVID-19 were observed. Thereafter, I gave the participants a form to fill in their profiles. Interviews were conducted before the lessons in order to get teachers' perspectives, experiences, and pedagogical insights regarding mediation of learning of the topic of chemical changes. Thereafter, I observed these teachers' lessons. These data gathering techniques were aimed to answer research question one and two which were:

1. What are teachers' perspectives, experiences, and pedagogical insights regarding mediating learning of the topic of chemical changes?
2. How do grade 9 Physical Science teachers mediate learning of the topic of chemical changes?

In this chapter, I present, analyse, and discuss data generated first from semi-structured interviews and second from lesson observations. This was done to find out whether the participants' explanations in the semi-structured interviews is what they practice during teaching and learning.

4.2 Development of Sub-Themes and Themes from Semi-Structured Interviews

Data generated from semi-structured interviews were first collated based on each teacher's responses to each question. Teacher 1 was coded as T1SSI and teacher 2 was coded as T2SSI (see Appendix I). The teacher's views, experiences, and pedagogical insights have some elements of commonalities and differences. Two main themes were developed and data generated from semi-structured interviews (SSI) are presented in those themes. Atallah, Bryant, and Dada's (2010) indicators of conceptions were used to come up with sub-themes (see Table 4.1).

Table 4.1: Themes and sub-themes from semi-structured interviews

Themes		**Sub-themes**
Teachers' perspectives regarding the topic chemical changes		-use of everyday experiences -use of examples with the class -use of natural resources with the environment -learners not bringing out their experiences -some learners not aware of the relevancy of the topic -be aware of learners' environments -everyday examples to enhance participation -learners regard it as new topic
	Teachers' enablers on the topic of chemical changes.	-useful and enjoyable -affordable and easily accessible materials -experiences from home -discussions of what is happening within the environment -bring out learners' experiences -use of practical activities
	Teachers' constraints on the topic of chemical changes.	-learners not practically oriented -learners' anti-social behaviour

Teachers' experiences and pedagogical insights		-lack of appropriate instruments -lack of IT devices -limited time -lack of laboratory materials -different levels of understanding of learners -lack of interest of learners to do practical work
	Teachers' understanding on how to make learners understand what they teach.	-different teaching approaches -activities which cater for all learners -repetition of explanations -hands-on tasks and observations -short homework and class activities -giving feedback of written work -do examples seen within the class
	Teachers' understanding if meaningful learning took place.	-appropriateness of answers from questions based on specific competencies - dialogue and discussions with learners -satisfactory written work from homework, tasks, investigations, and observations

Table 4.2: Themes and relevant literature from semi-structured interviews

Themes	**Relevant literature/Theory**
Teacher's perspectives/attitudes regarding mediation of learning of the topic chemical changes.	Kibirige & Van Rooyen (2006), Ngman-Wara (2016), Ostelude, Berg, & Ekborg (2010), Asheela et al., (2021), Lotz-Sisitka & Lupele (2012), Mavuru & Ramnarain (2020), Ghulum & Nyberg (2017), Erinosho (2013)
Teacher's experiences and pedagogical insights of the topic chemical changes.	Ngcoza & Chikunda (2014), Sedlacek & Sedova (2017), Atallah et al., (2010), Kibirige & Van Rooyen (2006), Kasanda et al., (2005), Maselwa & Ngcoza (2003), Asheela (2017), Osborne, Simon, & Collins (2003), Kaya & Ebenezer (2007), Chikamori et al., (2019), Vygotsky (1978)

4.2.1 Teacher's perspectives/attitudes regarding mediating the topic of chemical changes

When interviewed, two teachers expressed their views, experiences and pedagogical insights regarding the topic of chemical changes. When asked about their views and experiences regarding the topic, T1SSI indicated that the topic is useful as it has lot of examples from everyday life, therefore, everyday experiences and examples can be brought into the topic. The teacher pointed out that even though these experiences can be used, learners do not bring them out to participate fully when teaching the topic. In his own words he said: *"It deals with everyday experiences, which form part of the topic, but from my own observations, learners are not coming out to the topic*". This teacher points out that the topic chemical changes includes experiences from everyday life. The teacher thinks that these experiences are not brought up by the learners during teaching and learning. This may be because learners think that the topic is different from what they were taught in previous grades.

T1SSI also thinks that understanding the environment of learners is crucial as teachers have to identify examples found within the environment. These examples may be integrated in teaching and learning of the topic chemical changes. These responses provided by this teacher are explained by Kibirige and Van Rooyen (2006), that science lessons should be contextualised so that learners can be given an opportunity to extract from what they know from their homes and link it to school science experiences. By doing that, experiences from home and school experiences might be weaved together for the learners to understand the concepts (Erinosho, 2013). This supports Ngman-Wara (2016) that contextualising lessons should start with everyday observations so that it can be matched with the type of content to be learnt in the science lesson. Moreover, Mavuru and Ramnarain (2020) concur with Ghulum and Nyberg (2017), that teachers as mediators of learning have to come up with some strategies on how to elicit and use learners' experiences to promote context-based learning.

On the other hand, T2SSI alluded that the topic of chemical changes is not as challenging to mediate compared to other science topics. He explained that "*The topic itself, you have a lot of practicals that you can do of which learners can carry out without an investment of money or fund to buy anything"*. T2SSI acknowledged that the topic can be taught by utilising what is available within the environment. These materials can be identified by teachers, as long as they are safe to use in the classroom. The explanations agree with Asheela et al. (2021) who explains that when planning to teach and during teaching and learning, teachers should take into

consideration the use of easily accessible materials. This helps learners to make connections between what is being said and what is meaningful to them. It further provides inclusivity while at the same time deepens the understanding of the science concepts (Lotz-Sisitka & Lupele, 2012).

However, T1SSI, from his teaching experience, noted that when introducing the topic of chemical changes to the grade 9 learners, they normally regard the topic as a completely new topic which was not taught in the previous grade. He does not know what could contribute to this attitude of learners. He narrated that *"Grade 9 learners, most of them are not familiar with the topic chemical changes"*. T1SSI thinks that learners used to forget what they were taught and regard the topic as new to them. Moreover, they seem not to be aware that the changes which normally occur in their homes are part of chemical changes, for example, cooking and burning are examples of chemical changes in our everyday life. Thus, Osterlund et al. (2010) states that learners normally enter the learning environment with many experiences and examples of the topic of chemical changes without them realising it. For this reason, teachers should be well equipped to know how to assess what learners already know and use that as a starting point.

4.2.2 Teachers' experiences and pedagogical insights of the topic of chemical changes

T2SSI narrated that the topic of chemical changes is interesting and enjoyable. In his own words he explained that:

> *In my own capacity, chemical changes is an enjoyable topic because it is definitely one of the practical topics that I can definitely do with my learners. It is one of the interesting topics and it is not much challenging to teach like any other topics.*

This teacher argued that if the topic of chemical changes integrates what is easily accessible, it will be easier to mediate it and learners would probably enjoy the lessons. If learners enjoy lessons, they might possibly develop a positive attitude towards the topic. Osborne et al. (2003) argue that the attitudes towards science should be interest, enjoyment, value, and motivation. learners will have hands-on practical activities. Positive attitude towards the topic might help learners to develop the attitude of understanding the value of science in everyday life (Kaya & Ebenezer, 2007). Teachers should therefore be able to develop positive attitudes during teaching and learning.

The two teachers have different views on how they introduce the topic chemical changes. I find their ways of introducing the topic to be appropriate. For instance, T1SSI articulated that he introduces the topic by doing simple actions such as opening a window, moving a desk, and tearing and burning a paper to find out from the learners what types of changes they are. By giving examples which are within the classroom environment, I think it might help learners to focus and increase their engagement during teaching and learning. In addition, learners might also be aware that these some of the changes occurring form part of their everyday life. On the other hand, T2SSI responded that he introduces the topic by bringing in some available materials to show the learners how a chemical change happens. He said that "*I would sometimes bring in a matchstick, pieces of paper, piece of wood burned, and some little ash*". T2SSI further pointed out that after introducing the topic and giving examples, he would ask learners to think back to what happened in the environment in the past and what is happening in the present, and whether the changes occurring are physical or chemical changes. That is, learners will be able to think both retroductively and retrodictively (Chikamori et al., 2019). The teacher normally gives learners time to go and explore the science within the environment with what is taught in the classroom.

Moreover, if science lessons promote learners' interest, it might lead to their development in understanding the science concepts (Mukwambo, Ngcoza, & Chikunda, 2014). Teachers should probably engage learners in discussing chemical changes examples as they form part of our everyday life to enhance active participation (Sedlacek & Sedova, 2017). Based on what both teachers elaborated, the assumption is that learners' everyday experiences and prior knowledge should be able to motivate them to be active participants in class during teaching and learning of the topic of chemical changes.

Furthermore, these teachers normally do some lesson preparations which explains some steps to follow during mediation. For instance, T1SSI articulated that when planning, he thinks of some everyday examples, affordable and accessible materials, practical activities, and sometimes learners' experiences. He thinks of all those components during planning so that learners spent most of the time learning from each other while teaching and learning takes place. The teacher's explanations seemed to have the potential to promote social interactions which are pivotal to enhance sense making (Asheela et al., 2021).

Furthermore, Atallah et al. (2010) report that real life experiences and examples promote interest and confidence in learners. Likewise, T2SSI stipulated that the topic is practically oriented with available resources in which learners are required to think, investigate, and observe. Based on their explanations, these teachers seemed to be positive about using what is available to enhance the mediation of the topic of chemical changes. Similarly, Kasanda et al. (2005) expresses that, integration of learners' experiences empowers learners and it is one of the successful techniques in learning to understand the scientific concepts. The teachers have a belief that learners' experiences together with easily accessible materials are important, as learners might be more comfortable when using these materials (Kasanda et al., 2005). Additionally, learners will have practical engagement with the environment and be able to realise the relevancy of science in school to what is happening at home (Kibirige & Van Rooyen, 2006).

The teachers, reviewed that even though they are able to mediate the topic of chemical changes, there are certain challenges which they normally face. T1SSI pointed out that lack of a proper laboratory, science equipment, information, and technological devices (IT). I think this applies to most of schools in Namibia especially rural schools. Moreover, T1SSI thinks that specified time frame to complete the syllabus and planning some practical observations are some of other limitations on exploring more about science lessons. In addition to these challenges, T2SSI added that some learners are not practically oriented when it comes to practical activities. That is, they are not interested in performing practical activities. He further explained that some learners are anti-social, meaning that they are not interested in interacting with others. I think that the teacher should think of strategies on how to motivate those learners who are not interested in performing hands-on practical activities. In addition to that, T2SSI pointed out that classrooms are not conducive for practical activities due to lack of proper rooms and appropriate laboratory materials.

Some of the challenges mentioned by teachers are explained by Parker et al. (2018), that teachers are challenged with some science resources, limited time to carry out observations, and lack of pedagogical knowledge for science lessons. Even though there are easily accessible materials which can be used to mediate science lessons, it seemed teachers still need proper laboratories with suitable equipment, information, and technological (IT) devices. Lack of resources poses a challenge in performing hands-on practical activities. However, Asheela et al. (2021) articulate that easily accessible materials enable teachers to value their own lessons and become interested in sharing them with the learners.

These teachers normally evaluate their lessons by giving certain tasks and activities. T1SSI used to give practical work, class exercises, and examples which are familiar with the learners. In his own words he articulated that, "*everyday examples which I normally do explain some of the things for learners to understand"*. By what this teacher highlighted, there are some elements on the use of socio-cultural contexts of learners (Mavuru & Ramnarain, 2020) and resources which surround the learners. In light of this, Ronoh (2017) states that knowledge from social contexts bring about worthiness in science lessons. T2SSI pointed out that he normally does theory which I think is the content taught in class and perform doable practical activities in order to cater for the different levels of understanding among the learners. He has a belief that engaging learners all the time is the suitable method to mediate the topic. In this regard, Kasanda et al. (2005) recommend that teachers to apply interactive strategies and also pay attention on what to use to draw from learners' everyday contexts (Mavuru & Ramnarain, 2020).

These teachers seem to apply these strategies as T2SSI explained that:

> *Through questions and answers and sometimes in most cases, we do hands on task whereby the learners have to do a lot of practicals, they have to experience things, they have to see things happening, all in all I would say they should carry out observations*. (T2SS1)

To achieve what the teacher explained, different approaches of teaching should be applied while focusing on the understanding of concepts from the learners. Also, this teacher I think seemed to agree that practical activities through observing and handling objects might help learners to comprehend science concepts better. For that reason, Millar (2010) argues that practical activities should be part of teaching activities as they provide learners with an opportunity to observe and handle objects. In support, Asheela et al. (2021) propose that hands-on practicals should help learners to link ideas and theories of science during teaching and learning. When using hands-on tasks, it might strengthen the theory in class and the cognitive understanding of the learners. Moreover, T2SSI also pointed out that sometimes learners do not give clear answers that can help the teacher recognise their level of understanding of the topic, that is why a practical activity is required for better understanding of the different levels of learners.

These teachers indicated that if learners' work from given tasks, class activities, and homework are answered satisfactorily and match with specific competencies of the topic, they will know that learners understand what they are taught. From his point of view, T1SSI articulated that, "*I give short class activity, ask them individually to see if they achieved competencies of the lesson*

before I move forward". The activities given will show whether learners have mastered the concepts or not. In addition to that, T2SSI illustrated that he sometimes conducts a dialogue with learners, having discussions, doing presentations, and giving them investigations which they have to go and do at home. The techniques which the teacher uses also examines learners' understanding, that is, if they have developed skills and mastered the content. The explanation resonates with Vygotsky's (1978) theory that as learners are given autonomy of their own learning, they will construct meaningful learning through interactions with each other. When learners are doing investigations on their own, I think it might enhance their critical thinking and internalise what they are doing provided they are given clear instructions from the teacher. Both teachers agreed on the point which states that asking questions of the learners while teaching, helps learners stay focused.

4.3 Presentation and Data Analysis from Lesson Observations

The observations were made in order to complement data from semi-structured interviews. These observations provided first-hand information of what was really happening in the classroom during the mediation process (see Section 3.3.4.2). Teacher 1 was coded as T1LOB, teacher 2 was coded T2LOB and learners were coded as L. I observed three lessons from each participant. For teacher 1, I observed lessons over two days whereby lesson 1 took approximately 35 minutes and lessons 2 and 3 was a double period of approximately 70 minutes. Regarding teacher 2, I observed three lessons in three consecutive days. During these lesson observations, a colleague from these schools helped me to take some videos and pictures with permission from the participants and the learners (see Appendices D and E). The first part of these lesson observations will start with T1LOB and thereafter T2LOB.

4.3.1 Lesson observations teacher 1 (T1LOB)

The teacher started by greeting the learners and introduced me to them. Thereafter, he gave updates regarding Covid-19 and reminded learners to adhere to the safety regulations of the pandemic. The following was the classroom set up.

Figure 4.1: Classroom arrangement for T1

Figure 4.2: Coronavirus information inside classroom / sanitiser outside classroom

Lesson 1

The teacher encouraged learners to feel free and participate to their fullest. He continued by asking for work from the previous lesson and he moved around checking learners' work. Thereafter, the teacher wrote on the chalkboard 'matter' and asked learners what they could recall from the word. The learners gave the following answers:

L1: Everything that has mass and occupies space

L2: It occurs in three states

L3: Changes occurs in matter

The teacher then wrote on the chalkboard 'chemical change' and thereafter asked the learners what they understood by the written term or concept. The learners were silent. The teacher then asked learners to watch what he would do. He moved a bag which was next to him to a new position and then asked again what was meant by change.

L1: *When something is moved from one position to the next*

L2: When something is changed from where it was

The teacher continued by asking them, from what they had mentioned regarding matter, how they could define change in line with matter.

L1: *Changing the states of matter to different forms*

From that answer, the teacher outlined that there are two types of changes which occur in life. These changes were taught in the previous grade. He asked learners to recall two types of these changes. The learners were silent for a while. The teacher wrote on the board that these changes start with P and C.

L2: *Physical and chemical changes*

The teacher applauded the learner for recalling the type of changes. He reminded learners that the topic was taught in grade 8 and then in grade 9 more content is added. The teacher asked the learners to state the difference between these two changes.

L1: *Things moving to new things*

L2: Things like material and substances changing

L3: States of matter changing

The teacher informed the learners that when they are giving the difference between two types of changes, they have to give a clear distinction between the two. He explained that they need to state what belongs to physical change and what belongs to chemical change. The learners were silent and could not give an explanation.

The teacher then did the following demonstration in class. He folded a paper and squeezed it and then asked the learners the following questions: Is this still paper? What did I change by folding and squeezing the paper?

L1: *Yes, they are still papers*

L2: *The shape and size have changed*

Figure 4.3: Teacher squeezing a paper (example of physical change)

The teacher explained how a physical change occurs. He mentioned that in physical changes, no new substances are formed, they are easy to reverse, and heat is not always involved. Moreover, he explained that in chemical change new substances are formed, it is not easily reversed, and heat is involved. He wrote the following on the chalkboard.

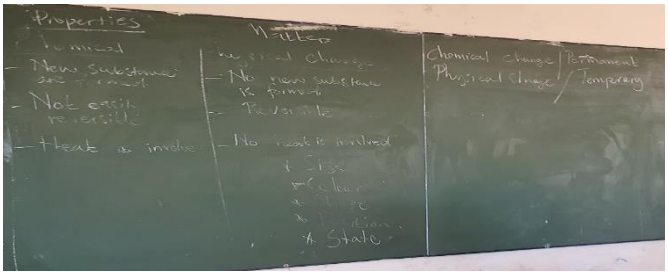

Figure 4.4: Summary on physical and chemical changes / explaining example of chemical change

Thereafter, the teacher lit a candle and gave it to the learner. He asked the class what type of changes had occurred, but learners could not give the type of changes.

The teacher then informed the learners that they should look at the candle and analyse what was happening with it.

L1: *Heat is involved*

L2: *Smoke involved*

L3: *Melting involved*

L4: *Rope burned*

The teacher instructed learners that from what they had mentioned, they should identify which ones were chemical changes and which ones were physical changes.

L1: *Rope burned is chemical changes because we cannot reverse it*

L2: *Smoke involved is a chemical change because it is a result of heat involved*

L3: *Wax is melting and then dry it is a chemical change*

The teacher asked learners whether wax melting is a chemical change or not. The learners indicated that it is a chemical change because the original shape cannot be reversed. The teacher explained why wax melting is a physical change. The teacher continued by asking learners if boiling water is a physical or chemical change. The learners indicated that it is chemical change. The teacher explained to the learners that the changes of state of matter are physical changes. These phase changes are melting, boiling, evaporation. A learner asked how evaporation is reversible. The teacher explained that this happens through the condensation process when a gas is changed to a liquid. He concluded the lesson by informing learners that they should come in the afternoon to copy notes from the chalkboard.

Lessons 2 and 3

The lesson started by checking learners' notes and homework. Learners were asked to mark the work themselves while doing corrections with the teacher. The activity was to classify given examples into physical or chemical changes.

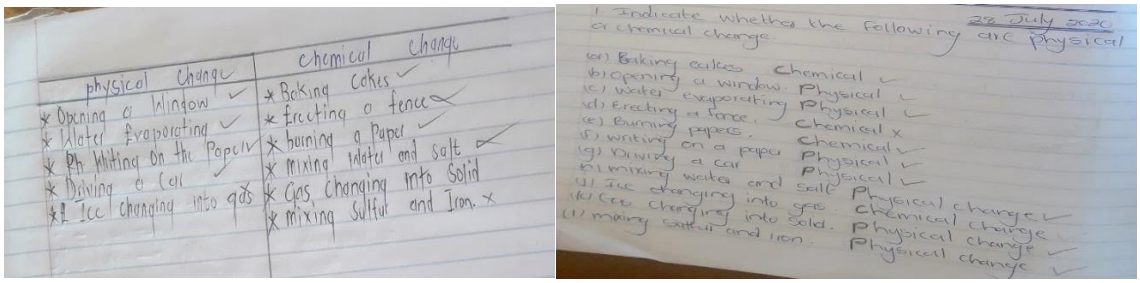

Figure 4.5: Learners' self-marked work

The teacher asked learners if they had any questions regarding the homework. The homework took almost 10 minutes. The teacher started by burning a candle as an example which was given in the first lesson. He then asked learners whether heat is involved when burning a candle or not. The learners gave the answer that heat was involved. He continued by asking learners whether the heat involved is taken in or given out. The learners answered by stating that heat is given out. The teacher explained to the learners that the scientific concept of *exothermic reaction* is used when heat is given out.

The teacher further gave an everyday example. He explained that when entering or leaving certain shops at the front of the doors they will see words such as entrance and exit. The word exothermic in a chemical reaction means energy is given out to the surroundings. The teacher gave another example of an electric kettle where water was let to boil. Learners were asked how heat is involved and whether it is taken in or given out. Learners pointed out that energy is involved and it is given out because of the vapour going out. Then the teacher called learners to come and see how the water starts to boil in the kettle. They saw that before the water starts boiling, bubbles start to form. The teacher made some follow-up questions such as where the bubbles came from, why the bubbles grew in size and is the heat taken in or given out. One learner answered by stating that the bubbles are formed from the heat gained. The teacher introduced another concept which was *endothermic reaction*. He further explained that endothermic reaction is when heat energy is taken in from the surroundings.

The teacher expressed that the two reactions are part of a chemical reaction. He asked learners to recall the properties of chemical reactions. Furthermore, he extended his explanation by outlining that chemical reactions come from substances which combine together chemically to form new substances. These reactions are said to be combined reactions. The teacher asked what combined reactions are. A learner answered by stating that it is when two things mix together. The teacher once again reminded the learners that whenever they mention mixing substances, it means that those substances can be separated. In a chemical reaction, substances form new products. He further alluded that the periodic table contains elements which combine together by reacting to form new substances. The learners were asked to mention some elements from the periodic table which they did as they have periodic tables in their exercise books.

The teacher gave an example by asking learners what is formed from hydrogen and oxygen when they react. Learners could not give the answer. He continued by trying to let learners think about

what is formed. He gave a directive by starting that it starts with W. Then a learner picked it up by mentioning water. The teacher wrote it on the chalkboard as follows:

Hydrogen + Oxygen ⟶ Water

Thereafter, the teacher asked them what they would call what he had written on the chalkboard. The learners were silent. The teacher explained that it is a word equation which has what is called *reactants* and *product*s. The teacher moved on by stipulating that a chemical reaction can be written in words and in symbols. He asked learners how to write the reaction between hydrogen and oxygen. A learner answered by mentioning that:

H + O ⟶ H_2O

The teacher explained to the learners that these elements are found as diatomic molecules in the atmosphere so they cannot be written like that in symbols. The teacher did not write the correct chemical symbol of the reaction between hydrogen and oxygen. Instead, he continued the lesson by asking learners what the name of the reaction was whereby a compound is given and you have to obtain simpler compounds or elements. Learners could not give the answer. So, what the teacher did was to direct the answer by informing the learners that the chemical reaction starts with a D. A learner remembered and mentioned decomposition reaction. A follow-up question was asked to the learners to explain the meaning of decomposition reaction. Learners were quiet, so the teacher simplified the question by asking learners what other names could be related to a decomposition reaction. A learner mentioned breaking. The teacher picked it up from there and explained thoroughly the meaning of decomposition reactions but did not give examples either by words or symbols by writing on the chalkboard.

The teacher moved on by asking learners if a decomposition reaction is an exothermic reaction or endothermic reaction. None of the learners could give an answer. The teacher paused and then asked learners what was used to break down substances.

L1: Machines are being used

L2: Electricity is being used

The teacher explained that all learners are correct and added that heat is also involved. Heat is used to break down substances and that heat is taken in. Decomposition reaction is an

endothermic reaction. The teacher gave another example of ice melting as an endothermic reaction. He explained that the change in temperature outside the refrigerator causes ice to melt. The heat is taken in to break down the bonds in ice, thereafter, it starts to melt. The teacher summarised the lessons by letting the learners know that they should be able to identify reactants and products in a word or chemical equation, differentiate between exothermic reactions and endothermic reactions and give examples of those reactions, and know what decomposition reactions are with examples.

4.3.2 Lesson observations teacher 2 (T2LOB)

The lesson started by introducing me to the learners and a colleague who helped to video record the lessons and take pictures. The teacher informed learners that I was a teacher like him so they should feel free to participate and ask questions where they did not understand. In school 2, they had the following in place for the purpose of following the protocols to curb the spread of the Coronavirus (Covid-19).

Figure 4.6: Sanitisers outside and inside the classroom

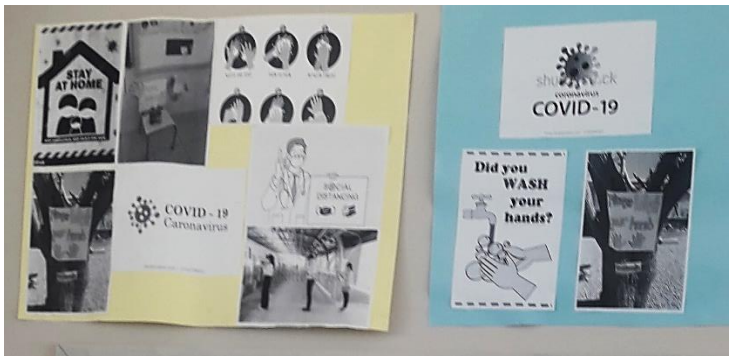

Figure 4.7: Thermo-gun for checking temperature of learners & COVID-19 information

Figure 4.8: Classroom arrangement

Figure 4.9: Classroom notice board charts for physical science

Lesson 1

The teacher started the lesson with an opening statement in which he stated that there are different changes in everything we do. Then he asked learners what change is. Learners gave answers such as changes in lifestyle, and changes in behaviour and attitude. The teacher continued by asking learners, what about the states of matter and how do they change? Learners gave answers such as changing in shape and size, changing in form. The teacher continued by pointing out that in grade 8 they were taught about the changes of matter. He asked them what the two types of changes are that they could recall from grade 8. Learners were quiet and he gave them few minutes to think about the question or check in the textbooks what types of changes they could find. A learner answered by giving two types of changes, namely, physical and chemical changes.

He then wrote the two type of changes on the chalkboard and asked them to define the changes.

> *L1: Physical changes is something which we can see with our own eyes and chemical changes we cannot see when it is happening*

> *L2: Physical changes is when things are there does not change completely and chemical changes things change completely*

The teacher took a paper, folded it and then squeezed it. He asked the learners what happened to the paper. Learners answered by indicating that the paper changed the shape and size but it is still paper. The teacher explained to the learners that those type of changes are physical changes. Thereafter, he summarised by writing on the chalkboard that in physical changes, no new substances are formed, when squeezing paper is still stays paper with the same properties. He also used an example of boiling water, that before boiling it was cold and after boiling it becomes hot but it is still water. He further moved on by making it clear to the learners that substances change from one phase to another and that these are the phase changes of matter, namely, melting, boiling, evaporation, condensation, sublimation, and re-sublimation/ deposition. The teacher burnt matchsticks and asked learners what happened to them. Learners gave answers such as a black substance was formed and that there was smoke. The teacher used learners' answers to explain what chemical change is. He explained to the learners that during a chemical change, new substances are formed and those substances are permanent. They are difficult to reverse and the properties of reactants and products are different.

The teacher asked learners if they could think of other examples of chemical changes. A learner answered by saying mixing sugar and salt. The teacher asked the learners if they agree or not but there was silence. Since learners were silent the teacher dissolved sugar in water as shown in the illustration below. He demonstrated this to show learners that the sugar dissolved in water rather than disappearing.

Figure 4.10: Sugar dissolved in water to correct the concept of disappearing

The teacher asked the learners that now they could see that he had dissolved sugar into the water why they thought it was a chemical change. L1 indicated that the sugar disappeared in water, L2 indicated that the sugar cannot be seen so it is difficult to reverse. The teacher then asked the learners follow up questions by referring to some of the industrial activities which happen on the coastal regions of Namibia. Learners pointed out that they are fishing and they produce salt. The teacher probed the learners by asking questions to find out if they understood the methods of separating mixtures and learners came up with answers such as sea water contains salt so the water is evaporated and the salt is collected. He then referred back to the sugar solution saying that as the sugar could be collected by evaporating the water, it is actually classified as a physical change.

One learner wanted to find out about a concentrated drink which is diluted in water. These liquids mix completely, so is it a physical or chemical change. The teacher explained to the learners once again that the word mix involves not heating the mixture so then the change is a physical change. The teacher showed examples to the learners of chemical change. He showed a tomato, onion and potato, eggs, and burnt paper and matchstick as examples of chemical changes.

Ripening tomato Rotten onion and potato Paper before burnt and after Eggs before fried

Figure 4.11: Examples of chemical changes in everyday life

The teacher explained that before the tomato changed to red it was green, the onion and potato were going rotten because a chemical reaction was taking place. If eggs are fried, they cannot be reversed so cooking results in a chemical change. The paper which was burnt resulted in a new substance and if too much burning happens in the environment, it causes air pollution as they saw they saw the smoke being produced. The notes were summarised on the chalkboard.

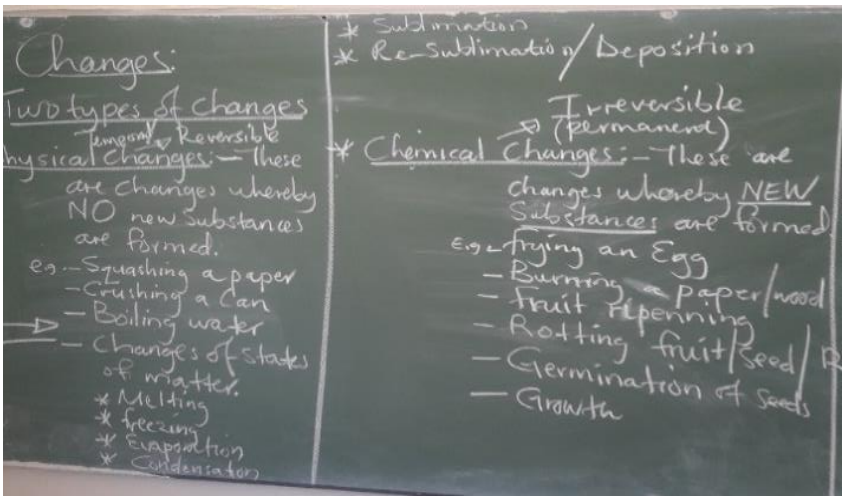

Figure 4.12: Notes on physical and chemical changes

The teacher summarised the lesson by asking learners to be very observant and learn about the chemical changes happening in their environment. As they left the class they should go and look around to check what physical and chemical changes were happening in the environment for them to come and report to class the next time they had a lesson.

Lesson 2

The teacher started by asking feedback from the learners about the work which they were given from the previous lesson. Learners started reporting on physical changes examples such as stones breaking, bottles and plastics broken, washing and drying clothes, and cleaning. On chemical changes, they gave examples such as wood burning, cooking food, wood getting dry on its own, and iron zincs which they use to change the colour of walls. The teacher applauded the learners for their insightful observations which they made within the environment. One learner brought grass to the class because he was not sure whether to classify it as a physical change or chemical change.

Figure 4.13: Dried grass as an example of chemical change brought by a learner

The teacher asked the learners that before the grass changed colour, what colour was it. The learners answered that it was green and then it changed to brown. The teacher continued by asking the learners if the grass can be reversed to its original colour. The answer was no and then they gave the answer by indicating that it was a chemical change. He continued by making a point that leaves falling from a tree is a chemical change. The teacher continued by writing an activity on the chalkboard and let learners complete the activity.

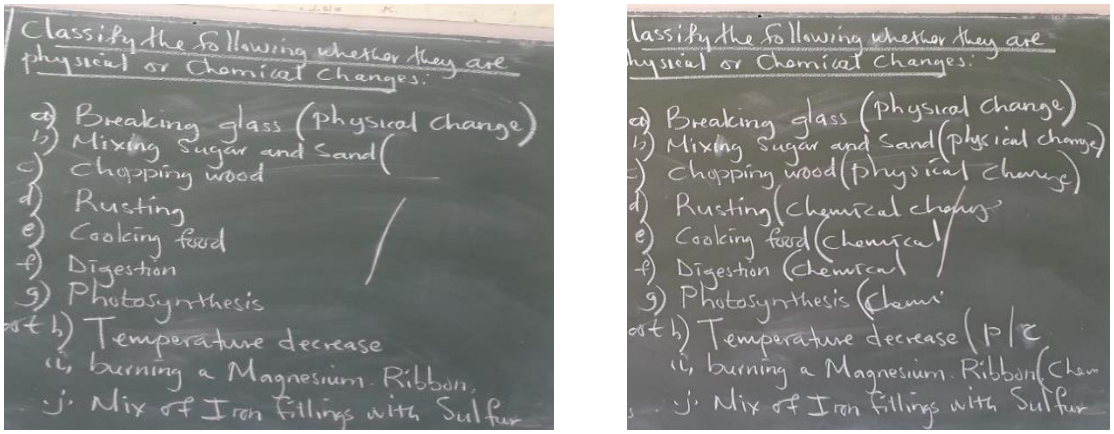

Figure 4.14: Class activity and corrections

Learners copied the activity from the chalkboard into their exercise books indicating whether the examples given were physical or chemical changes. As the learners were writing, the teacher

moved around checking whether the learners were really doing the activity or something else. Then later, the teacher asked learners to start marking their own books and do corrections on the chalkboard. The teacher concluded the lesson by giving prepared notes to the learners.

Lesson 3

The teacher started the lesson by asking questions based on the previous lesson. The participation of learners was average because some of the learners were quiet when they were pointed at to give answers. Thereafter, the teacher started explaining that whenever a chemical reaction starts, energy is always involved. He continued by stating that in all the chemical reactions which they discussed from the previous lesson, energy was involved. This energy was either taken in or given out. He asked learners to recall from the previous grade if they learnt about chemical reactions where heat was taken in or given out. Learners were silent. The teacher struck a matchstick and a flame was produced. He then asked learners why a flame occurred. A learner answered by indicating that it is because of the black stuff on the match box. The teacher explained the role of oxygen in the air in the burning process. He continued by asking learners if the heat is taken in or given out. The learners answered that heat is given out. Thereafter, the teacher explained that when heat is given out to the surroundings, that type of reaction is called *exothermic reaction*. When the heat is taken in from the surroundings, that type of reaction is called *endothermic reaction*.

The teacher thoroughly gave some examples of exothermic and endothermic reactions by engaging the learners using questions. The notes were written on the chalkboard.

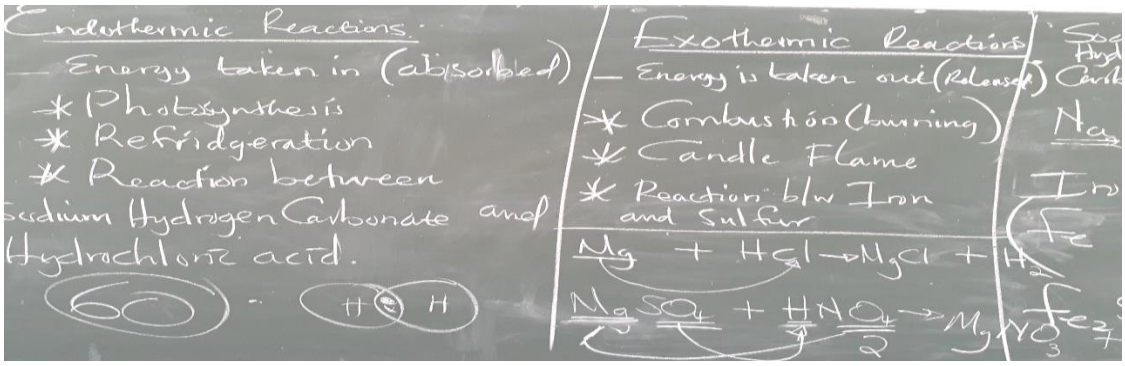

Figure 4.15: Notes on exothermic and endothermic reactions

From the notes which were written on the chalkboard, the teacher asked learners if they could give examples of exothermic and endothermic reactions from everyday observations. Learners gave examples such as cooking, and making a fire. The teacher brought in a new concept of

rusting. The teacher explained that some materials such as metals rust. They change colour which is caused by the reaction between oxygen and the metal and it is called ‘rusting’. He further explained that rusting is the cause of the reaction between the iron and oxygen so it is a combustion reaction. He showed the following example of rusting.

Figure 4.16: Spoon and knife showing rust

He explained to the learners that a chemical reaction took place between the metal and oxygen in the air that is why there is a coating of brown substance on the spoon and knife. Water can cause rusting as well. So he wrote the following equations:

Iron + Oxygen $\longrightarrow$ **Iron Oxide (rusting)**

Fe + O_2 $\longrightarrow$ **Fe_2O_3**

He continued by emphasising that, the chemical reactions which took place can be written in words and in symbols. Balancing of equations was not the focus at this time of teaching and learning. He used the following easily accessible materials to explain chemical reactions and how to write word and chemical equations. He supplemented this demonstration to strengthen the concepts of exothermic reaction and endothermic reaction. Learners felt the test tubes by comparing their hotness and coldness.

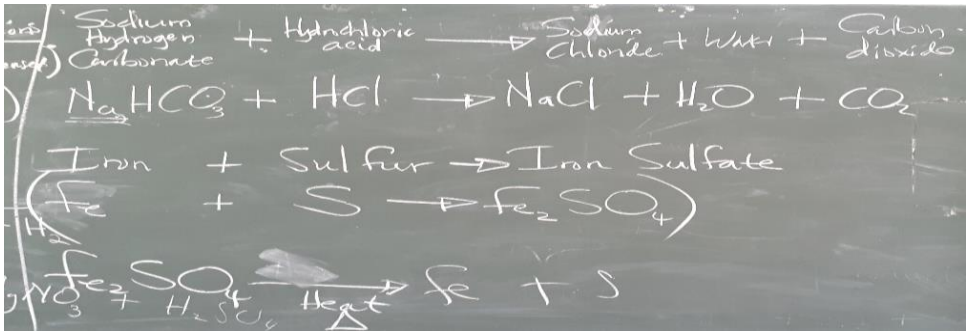

Figure 4.17: Easily accessible materials, word equations and chemical symbols

The teacher outlined that in every exothermic reaction in which he gave an example like burning, the initial energy is needed to start up a reaction. This type of energy is called *activation energy* which is the initial energy that is needed to start up the reaction. He interpreted that in chemical reactions there are reactants and products in both word equations and chemical equations. The substances before the arrow are *reactants* and substances after the arrow are *products*. The teacher concluded the lesson by giving the following activity to the learners to copy into their exercise books and give answers.

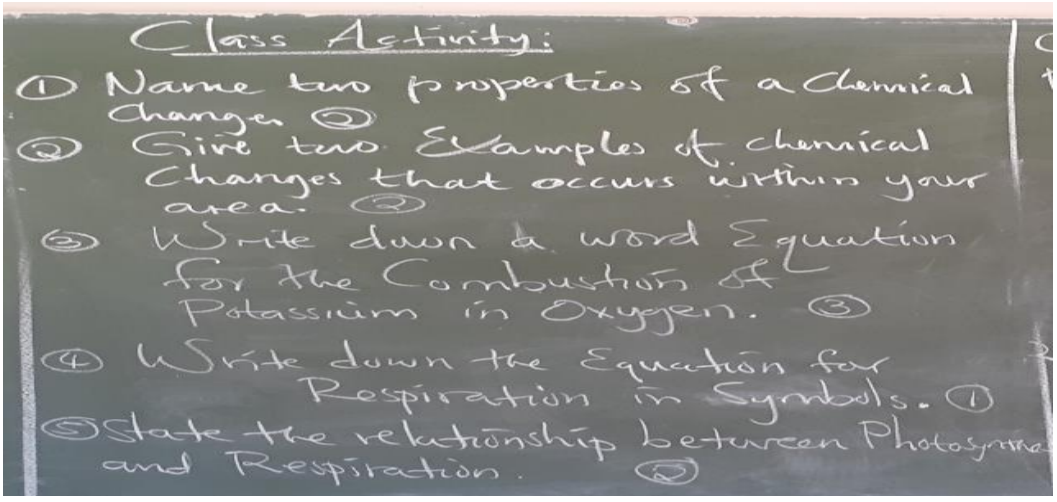

Figure 4.18: Class activity after the lesson

The teacher urged learners to complete the activity so that he could collect the exercise books and mark them. When analysing the data from teachers' observations, TSPCK was used as an analytical tool and the following themes emerged to answer research question 2:

How do grade 9 Physical Science teachers mediate learning of the topic of chemical changes?

Table 4.3: Sub-themes, themes and relevant literature/theory

Theme	Relevant literature
Teachers' Pedagogical Knowledge on the topic of chemical changes -learners' prior knowledge -curricular saliency -what is difficult to teach -representations -conceptual teaching strategies	Roschelle (1995), Kuhlane (2011), Rennie (2011), Oloruntegbe & Ikpe (2011), Mavhunga & Rollnick (2013), Mavhunga et al. (2016), Loughram, Berry & Mulhall (2006), Leach & Scott (2003), Van Driel (2010) Asheela et al. (2017), Ndevahoma (2019), McRobbie & Tobin (1997), Vygotsky (1978), Mavuru & Ramnarain (2017), Shinana (2019), Shifafure 2014
Mediation tools used of the topic chemical - language - teaching methods - easily accessible materials	Lemke (2001), Leach and Scott (2003), Brock-Utne (2001), Msimanga & Lelliott, 2014; Mavuru & Ramnarain, 2017).

The data from these two teachers illustrates how the mediation process (Vygotsky, 1978) took place in science lessons. In Chapter Three, I explained the purpose of observations (see Section 3.3.4.2). This chapter presents and discuss the data using the TSPCK components from Mavhunga and Rollnick (2013), namely, learners' prior knowledge, curricular saliency, what is difficult to teach, presentations of analogies, and conceptual teaching strategies. This TSPCK was used as an analytical tool for the purpose of assisting me to understand how these teachers mediated learning of the topic of chemical changes. The TSPCK determines how teachers have to transform content knowledge (CK) into meaningful learning. Meaning that, teachers had to contextualise how best their learners can learn regarding the topic.

4.3.3 Teacher's pedagogical content knowledge of the topic of chemical changes

As the research was triggered by examiners' reports and personal experiences, it could be argued that teachers' knowledge influences all aspects of teaching such as lesson preparation, the type of content to be taught and what to be used (Van Driel, 2010). Moreover, according to Shulman

(1986; 1987), in order for teachers to be able to mediate learning effectively they have to know suitable activities, analogies, demonstrations, or simulations which are done through the PCK of teachers. A thematic approach was used to analyse the data. The five components of TSPCK from Mavhunga and Rollnick (2013) were identified in which inductive-deductive data analysis was used. The discussions are as follows:

Learners' prior knowledge

This component refers to mediation which has to start with eliciting learners' prior knowledge and paying attention to the misunderstandings learners have regarding the topic. The component requires teachers to come up with some alternatives on how to correct the misunderstandings of learners. From the observations of these two teachers, they started their lessons by drawing from learners' prior knowledge. Teacher 1 (T1LOB) asked questions to the learners and through the process of teaching and learning, he pointed out that "*in life, there are types of changes which occurs, what type of changes have you learnt from the previous grades*?". Similarly, Teacher 2 (T2LOB) also started with a few questions and continued by stating that "*there are two types of changes which occur in our everyday life, what type of changes can you recall*?". By observing how these two teachers introduced their lessons, it was evident that they both acknowledged the importance of prior knowledge in teaching and learning of science. Roschelle (1995) makes it clear that prior knowledge is central to learning of new concepts as it affects the way learners perceive new information. These two teachers expected learners to have prior knowledge regarding the topic of chemical changes. The prior knowledge guides the teachers to identify what pre-concepts learners have regarding the topic.

Through mediation of the learning process these teachers kept on relating to what learners knew regarding the topic of chemical changes. For example, T1LOB asked learners "*do you all know what are temporary changes, these changes are found everywhere, where we are now in the classroom and even at home. Can you come up with those examples*?". It was evident that these teachers tried to constantly refer back to learners' past understanding and experiences regarding the topic. In support of this, scholars such as Kuhlane (2011), Rennie (2011), and Oloruntegbe and Ikpe (2011) argue that it is imperative to integrate prior knowledge during mediation of learning as it enables learners to understand new concepts better. They assert that inclusion of prior knowledge enhances conceptual understanding.

Notably, in order for learners to understand the content of their lessons these teachers used examples which were within the learners' socio-cultural context as emphasised by Mavuru and Ramnarain (2020). For example, T1LOB used examples such as tearing a paper, opening a window, opening a door, moving a desk while T2LOB used dissolving sugar and folding papers to explain the concept of physical change. On chemical change, they used examples such as burning paper, burning a matchstick and in addition to that, T2LOB brought examples such as ripened tomatoes, rotten potatoes, germinated plants, and other easily accessible materials found within the context of the learners.

During mediation of learning, however, learners worked alone. That is, they did not share their experiences with other learners regarding the topic of chemical changes. This finding is not congruent with Mavhunga and Rollnick's (2013) and Mavhunga et al.'s (2016) proposition that learners should work in groups to share prior knowledge regarding certain things. If these learners were granted this opportunity, I think they might learn more new information from each other. Therefore, I regard this as a missed opportunity which learners could experience/explore.

Curricular Saliency

The component requires teachers to know the sequencing of the curriculum and identify the most important concepts around the topic. These concepts are referred to as 'big ideas' by Loughram, Berry and Mulhall (2006). During mediation, teachers are supposed to identify these big ideas before mediating the topic of chemical changes. The big ideas according to Loughram et al., (2006) are considered as an imperative tool associated with the PCK of teachers. By knowing these big ideas, the teachers might be able to identify the level of understanding of learners on the topic of chemical changes. During the lesson observation, both teachers asked some questions from the leaners. Thereafter, they wrote down topics to be taught on the chalkboard. They further gave explanations after learners' answers and introduced other concepts such as *exothermic reactions, endothermic reactions and decomposition reactions*. They asked multiple questions regarding the concepts and subsequently gave explanations thereof. It could be surmised that the teachers' explanations were an indication of curricular saliency.

However, even though main ideas where identified, I did not see teachers showing learners how the concepts of chemical change were related. For example, showing a concept map of the topic chemical changes. This is significant as Mavhunga and Rollnick (2013) allude that considering the interrelated links between concepts and sequencing them, enables learners to move towards

what is required to be taught. In my view, a concept mind map with linking words could possibly have helped teachers to identify the gaps when mediating the topic of chemical changes. The strategy of questions and answers did not demand much from the learners to know how the concepts were linked. From this observation, it seemed that the curricular saliency for teachers still needed to be strengthened.

What is difficult to teach?

This component deals with teachers identifying particular concepts which are considered difficult to teach and pose a challenge to the learners. For example, from the learners' activity which was given by T1LOB, I could see that learners still confused examples of physical change to those of chemical change. That is, the examples which T1LOB used to mediate learning were not adequate for the learners to be able to differentiate physical and chemical changes. It seemed that learners needed more practical examples which could be observed and some scientific concepts were not understandable to the learners. Concepts such as exothermic and endothermic reactions, reactant, products and others could be strengthened by performing practical activities. I observed in a lesson with T2LOB that a learner gave the example of mixing sugar and water as a chemical change. A learner reasoned by stating that "*the sugar disappeared, it has changed to another form*". I felt that since the teacher demonstrated that the sugar dissolved, he should have completed the process by performing an evaporation method to separate the mixture in order to address the misconception of this learner and for the benefit of other learners. The explanation itself was not enough for the learners to understand the type of change which occurred. Even though T2LOB tried to probe learners on an industrial example of how salt is extracted in one of the coastal towns in Namibia, most learners were not aware that such methods of extractions exist in the country.

T1LOB also asked learners whether boiling water was a physical or chemical change. A learner answered by stating that "*the water will boil and heat is involved, so it is a chemical change*". The answer which was given by this learner is an indication that they did not perceive the content in detail. I think a teacher should first assess what learners know about un-boiled and boiled water. Thereafter, questions could possibly follow. Loughram et al. (2006) point out that science content to be taught and teaching practice should be considered when mediating topics.

On the concepts of exothermic reaction and endothermic reaction, T1LOB used examples such as boiling water and burning candles which were used at the introduction of the topic. In my

view, I felt that the teacher should have brought in other examples where learners could have been given the opportunity to make predictions and observe for themselves. The examples were not adequate enough for learners to understand. As a result, teacher-talk dominated the mediation rather than learner-talk interaction.

Representations of the topic of chemical changes

This component requires teachers to plan what type of presentations they are going to use to mediate learning of the topic of chemical changes. These are regarded as teaching strategies to be used. This includes strategies of the subject content to be taught, the learning activities planned, instructions on practical activities, and the nature of assessments given to the learners. Moreover, Mavhunga and Rollnick (2013) and Mavhunga et al. (2016) express that presentations can be illustrations, metaphors, demonstrations, experiments, analogies, models, or stimulations used during mediation. For example, T2LOB on the difference between exothermic reaction and endothermic reaction used baking soda, aluminium foil, two test tubes, test tube holders, hydrochloric acid, and two balloons as seen below.

Figure 4.19: Chemical reaction taking place: Aluminium/hydrochloric acid and sodium hydrogen carbonate/hydrochloric acid (exothermic and endothermic reaction)

Learners touched the test tubes with caution from the teacher. One was hot while the other was very cold. Both reactions produced some gases as balloons were inflated. The way he presented the concepts using hands-on practical activities made learners eager to observe and concentrate on what was going to happen. However, there was a missed opportunity for learners to share what would happen before the experiment was demonstrated by the teacher. For instance, Van Driel (2010) posits that teachers should use practical resources which are available and familiar to the learners for them to understand the science concepts in detail. Furthermore, Leach and

Scott (2003) point out that conceptual development is more likely to take place if the planned activities are relevant to the context. The experiment which T2LOB presented to the learners helped him to mediate learning in his lesson 3 of identifying reactants and products. He could clearly show learners what was used before and what the end products were as shown below.

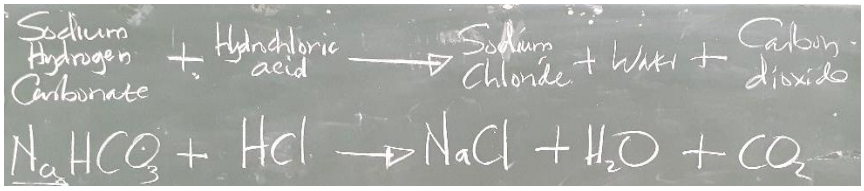

Figure 4.20: Showing reactants and products

The way the teacher tried to mediate learning in this topic concurs with what he pointed out in the semi-structured interviews: "*the topic is based much on practicals and the use of available resources".* Even though teacher 1 stipulated that "*you bring what is affordable and accessible within the environment"* in the semi-structured interview, there were no aids from the environment to support mediation of learning of the topic of chemical changes, despite ease of accessibility. Asheela et al. (2021) and Ndevahoma (2019) argue that using easily accessible materials allows the learners to better understand the science around them.

Conceptual teaching strategies

This component requires teachers to consider the other four components so that appropriate teaching strategies could be chosen. These teaching strategies should help learners to clear misconceptions and enhance conceptual understanding. The way teachers planned their teaching strategies influences the learners' understanding on the topic. On this component, T1LOB planned his lessons (see Appendix J) while T2LOB planned notes and activities which he wrote on the chalkboard. The planned lessons from T1LOB and notes and activities from T2LOB were according to the specific competencies from the Physical Science grade 9 syllabus.

During lesson observations, these teachers employed a question and answer method, lecturer method, and a few demonstrations. T2LOB did much of the writing and drawings on the chalkboard while T1LOB did much of the talking with little written notes. The presentations through lecturing dominated both their mediation processes which resulted in little learner participation. Mavhunga and Rollnick (2013) suggest that teaching of science should be accompanied by practical demonstrations for conceptual understanding. Even though T2LOB

used easily accessible materials to support teaching and learning, he talked more than the learners.

Demonstrations done by T1LOB and T2LOB were in line with Vygotsky's concept of ZPD. The learners observed what was happening, so they could think about it and give their analysis. In support of this, McRobbie and Tobin (1997) assert that involving learners in teaching and learning allows learners to have autonomy and relevancy to what they are learning. Moreover, Vygotsky (1978) emphasises that learners' understanding needs to be directed for them to reach their ZPD in understanding topic concepts. The demonstrations and illustrations which teachers incorporated in presenting lessons promoted some discussions and McRobbie and Tobin (1997) encourage that teachers need to be creative enough to make sure that learners are actively involved in the lessons.

T2LOB in his lesson presentations used easily collected materials which are part of everyday life situations to present examples of chemical changes. These examples resonate with Mavuru and Ramnarain (2020) and Vygotsky (1978) that drawing from learners' socio-cultural context enables learners to make sense of the concepts. The use of easily accessible materials is supported by studies conducted by Asheela et al. (2021), Ndevahoma (2019), Shifafure (2014) and Shinana (2019) where it was found that easily accessible materials enable learners to enjoy learning as they make links between the materials used with the content and concepts being learnt. The activity which T2LOB gave to the learners stimulated their minds as he gave them an opportunity to go and explore, do observations and come up with physical and chemical changes which occur within the environment and at home.

4.3.4 Mediational tools used of the topic chemical changes

Mediation involves resources used in teaching and learning to make the learning content understandable to the learners. I observed two teachers mediating learning and identified the tools used in the process. These mediating tools were language and easily accessible materials.

4.3.4.1 Language as a mediational tool of the topic chemical changes

Both teachers used language during the mediation process. Vygotsky (1978) explains that cognitive development is mediated through language. During lesson observations, the language of instruction which was used in mediation was English. Learners in the schools where the study

was carried are taught in their second language English. The everyday spoken language and scientific language were also used during mediation of lessons.

For example, T1LOB used coming in and going out to explain the concepts exothermic reaction and endothermic reaction. Furthermore, when a learner stated that sugar disappeared in the water, T2LOB directed the learner by articulating that the sugar dissolved in water. Thus, Khurama and Shama (2015) illustrate that during mediation, there must be an understanding between the learners' language and the teacher's language in order to create an understanding of scientific language.

Moreover, the teachers used the technical language involved in the topic of chemical changes such as reactants, products, reversible, chemical reactions, exothermic reactions, endothermic reactions, evaporation, chemical symbols of elements, compounds and others in their presentations. As espoused by Vygotsky (1978), language contributed to social interactions between the teachers and the learners. T2LOB who gave many examples of word equations and chemical symbols, took much time in explaining these formulas. T1LOB did not do much when it came to writing word equations and formulas.

From my observations, it appeared that there were limited interactions between learners themselves and there was an imbalance between teacher talk and learner talk. The question-and-answer method which was used in the mediation process only allowed learners to give short answers. This is opposed to what Lemke (2001) suggests, that learners develop the language of science when they are given more time to participate in the classroom. Learners' participation was limited especially in T1LOB's presentations. This might be caused by what Leach and Scott (2003) point out, that learners think in their own language better during teaching and learning.

In addition to that, Brock-Utne (2001) also argues that language is one of the learning difficulties which learners are challenged with during teaching and learning. Teachers could express themselves freely in English but repetition of concepts, questions, and rephrasing of statements was observed in order to help learners think and come up with answers to the questions. The learners tried to figure out what type of language and questions were being used and asked by the teacher and at the same time they were trying to learn the language of science. Learners were faced with a double challenge of trying to follow the language of instruction and at the same time learning scientific language (Mavuru & Ramnarain, 2017; Msimanga & Lelliott, 2014). Thus,

this might have resulted in learners being passive due to the language of instruction used in the classroom.

4.3.4.2 Using easily accessible materials as mediating tools

Both teachers tried to complement their mediation of learning using what was available and affordable, not forgetting the level of understanding of their learners. For instance, T1LOB used examples and demonstrations of squeezing a paper, opening the door, and moving a bag which was within the classroom so that learners could see. Meanwhile, T2LOB brought in materials that were affordable, known to the learners, and in line with what was supposed to be achieved at the end of the lesson. The objective of both teachers was to see to it that at the end of their lessons, learners could understand the topic of chemical changes.

Through mediating learning with easily accessible materials (Asheela et al., 2021), some learners who could easily follow the lessons, realised that these changes occurred in their everyday life. For example, when the teacher was explaining rusting, I observed that they did not have to figure out what it was. Immediately when the teacher showed the rusted spoon and knife, they figured it out in their own language as '*omureru*'. They related what they knew from home to what they were learning in the classroom. That is why Shizha (2013) explains that teaching practices in the classroom should reflect the social and cultural contexts of the learners.

4.4 Chapter Summary

In this chapter, I presented data from semi-structured interviews and lesson observations. This was aimed at answering research questions one and two. The data from semi-structured interviews showed that teachers have ideas and knowledge of using everyday experiences, easily accessible materials, practical activities. However, there is still need to strengthen the curricular saliency and conceptual teaching strategies during teaching and learning. Teaching strategies are crucial as the whole mediation process is based on those strategies.

During lesson observations, it emerged that teachers still need to improve on practical activities and a learner centred approach. For instance, the lesson observations revealed that teachers relied more on traditional methods of teaching and learning rather than a learner centred approach. In the next chapter, I now turn to discussing data from stimulated recall interviews and teachers' reflections

CHAPTER FIVE: STIMULATED RECALL INTERVIEWS AND REFLECTIONS

5.1 Introduction

This chapter presents data from stimulated recall interviews and reflections done by the participants based on lessons taught. The reflections and stimulated recall interviews were done individually on different dates based on the participants' availability. The purpose of doing stimulated recall interviews and reflections are explained in (see Sections 3.3.4.3 and 3.3.4.4). These data gathering methods were done when participants had free time to avoid interfering with the teaching programme, as the COVID-19 pandemic disrupted much of the teaching and learning programmes. Each videotaped lesson was shown to the participants to do some reflections. This was done because I wanted to understand their actions, thoughts, and views about lessons taught. Furthermore, reflections served as a recall from what transpired during lesson presentations and how these teachers viewed their lessons. Thus, it gave me more insight on the mediation of learning of the topic of chemical changes. The research question which was answered was:

> What lessons appear from teachers' reflections after mediation of learning of the topic chemical changes?

5.2 Responses from Stimulated-Recall Interviews and Reflections

Teacher 1(T1) expressed that he felt good to see himself on a video teaching the learners. He further said that the practice of taking videos should be done regularly and those videos saved for future reference. T1 thinks that video recorded lessons can be kept safe and used make comparisons with other lessons. He felt that the practice can guide a teacher on their planning and teaching practices. He further felt that learners might also feel good if they see themselves in the videos with a teacher. He stressed that as the school is in a rural area some of the learners are not aware about recording lessons which they could watch. Moreover, he added that it would

encourage learners to participate in class as well. The teacher further explained that he could see where he lacked and teacher talk dominated his lessons.

Similarly, Teacher 2 (T2) reflected that it was so interesting to see himself in the video with the learners. He did not imagine that learners were listening attentively while mediating learning. He pointed out that even though the learners participated, he acknowledged that he talked more than the learners. This is opposed to Lemke (2001) who proposes that during mediation of science lessons, there must be a balance between teacher talk and learner talk.

Regarding the lessons, T1 explained that the lessons were planned according to the stipulated competencies of grade 9 Physical Science syllabus (Namibia, MoE, Syllabus, 2015). He indicated that the lessons were completed as planned but then, learners did not participate much. He elaborated on reasons such as learners being on a long holiday due to the COVID-19 pandemic and that online learning did not materialise. He commented that online learning was practically impossible as network coverage in the villages are poor. Learners do not have smart phones and the few who do, cannot afford to have data all the time. T2 also shared the same sentiments that, "*E-learning was the worst mode ever introduced in the Namibian learning system as it does not favour everyone"*. It was not possible to reach out to every learner with teaching and learning materials. Furthermore, only few learners have access to electronic devices. Due to that explanation, face-to-face learning for now is considered to be the best approach for teaching and learning. From what these teachers shared, it concurs with Nunes (2020) that the COVID-19 pandemic highlighted some of the inequalities such as unequal access to education.

In addition, T1 enumerated that even though the topic was taught in the previous grades, it seemed that learners could not recall the content and concepts. On the other hand, T2 argued that his lessons were so good and interesting. He was happy about the participation of his learners even though he talked more. He outlined that "*lessons were so good and so interesting as participation was quite good and most of the learners participated as I brought those materials known to them*". Teacher 2 thinks that the supporting materials which were used to mediate learning influenced learners to participate and be interested in the topic. Based on what was T2's explanations, it concurs with Mavuru and Ramnarain's (2017) assertion that if learning is associated with the cultural setting of the learners, they will show interest and relate it to what they already know. Through planning lessons and activities, T2 was innovative to come up with

resources to support his mediation. Stears et al. (2003) demonstrate that the knowledge of resources can help a teacher to relate the content of the subject to what should be used to mediate lessons effectively.

Regarding the activities which were planned during the mediation of learning, T2 illustrated that he planned those activities based on what was supposed to be achieved by the learners. The supporting materials which he used were just from the surroundings which were familiar with the learners. He further argued that there is no need to worry about laboratory chemicals and equipment. He explained that the materials brought to class "*allows them to be able to see raw materials that are surrounding them, whereby they can be able to explore chemical changes taking place within the surrounding and science in the classroom*". By using materials which are available, I think it might help learners to understand that science is not about the content taught in the classroom but found everywhere within the environment.

Furthermore, T1 reflected that the activities which he did with the learners, were the basics of the topic and learners could pick out something to learn from them. He stated that the activities and examples which he gave, "*were simple examples that is at the level of the learners at my school*". The explanation resonates with Vygotsky's concept of ZPD that learners learn best when the mediation is within the level of their understanding. Both teachers' mediation used one-on-one interactions which I felt were important during the pandemic of COVID-19 as learners were attended to individually. Learners who could not answer the questions, benefited when the teacher attended to them.

T1 also made a point by explaining that he came up with examples which were less costly and that as they are in a rural area, they struggle to get the resources stipulated in the syllabus and other resources which are to be downloaded from media. He further outlined that through examples such as burning a candle and burning a match, learners could see light, feel the heat, and see the wax melting which were regarded as physical and chemical changes that occur in our everyday life. Teacher 1's explanation is an indication that science does not necessarily depend on laboratory equipment and media devices, but can be made easily accessible to the learners by using local materials (Asheela et al., 2021). The explanation is supported by Kuhlane (2011), that science is everywhere and we are surrounded by it. However, I acknowledge that the laboratory materials and equipment should not be neglected if they are available in schools or

can be borrowed from teachers' resource centres. Both types of learning materials can complement each other to support the teaching and learning.

When the teachers reflected whether learners understood the topic and concepts, T1 acknowledged that there were some concepts which he felt that he did cover enough. He mentioned concepts such as *exothermic, endothermic, reactants*, and *products*. He further mentioned that looking at the examples which he gave from everyday experiences, he did not give details to justify the concepts. Even though the learners understood some concepts such as permanent change, temporary change, and easily reversible, he still needed to do more on the topic. Meanwhile, T2 thought that learners understood the topic because what they wrote from the activity which he gave was quite satisfactory. As he explained in the T2SSI, he sometimes knows that learners understood what he taught from the written work. However, he critiqued that learners still needed to practice how to write word equations and chemical symbols of chemical reactions. He noted that learners did not master that competency well. All in all, T1 explained that if you have to mediate science topics effectively he realised that a teacher should always start to familiarise themselves with the concepts or terms found within that topic.

Both teachers felt that there were some missed opportunities in their lessons which could be strengthened. T1 asserted that *"I could do something different by preparing thoroughly, do more research on the topic and bring different types of resources for learners to understand*". He further stipulated that he would allocate time to do some demonstrations and practical activities. By doing that, learners could come up with their own examples based on what they saw and understood. From what he observed from the video lessons, he pointed out that he lacked in those aspects. Similarly, T2 also noted that he did not let learners draw conclusions from the few things which he demonstrated in class and noted that he should not ignore practical activities, which he would improve on the next time. On a positive note, T2 alluded that during his mediation he learnt something from the learners when they had to gather examples of physical and chemical changes taking place in their everyday life. He stated that on chemical changes, "*I noticed that there are a variety of them from what I already know, it added some insights of some of the examples which I did not know".* He continued by pointing out that, "*I learnt more, the lessons themselves gave me the highlight of what is going on within the surrounding*".

T2's explanations showed that there was a shift in his ZPD as well. This concurs with Shabani (2016) who argues that shifts in development can also occur in teachers as it influences them to

improve on their teaching practice. Moreover, T2 was content that he also learnt something from the topic's content and that learners were able to explore and develop the skill of analysing what was happening in their environment. He explained that, "*I have learnt a lot as well, little did I know that more examples will emerge from learners' observations*". He enjoyed the lessons and he was empowered by watching the lessons on the videos.

These teachers were also asked to reflect on the whole research process and how they felt about it. T1 reflected that the research was an eye opener to him; he appreciated that it was communicated on time, the researcher arrived on time, and it motivated him to be prepared to teach his lessons. Through preparations he managed to mediate all the lessons which he prepared. The teachers and I know each other from science workshops and clusters, fostering a relationship of trust. He explained that the research gave him a positive feeling such as being creative to think of resources which are related to the topic. He was energetic and tried to give an accessible lesson to the learners. He further alluded that this research "*showed me that I need to be prepared all the time because honestly, there is sometimes a relaxation of planning, bringing in resources and support the teaching and learning"*. He continued by stating that if you are not fully prepared as a teacher, it will affect the way you teach.

In addition to that, T2 also pointed out that the research made him more focused when teaching and that the visit motivated learners to be confident when answering questions. T2 stressed that "*if you plan and allocate your time effectively, there is maximum utilsation of teaching and learning*". He also observed that because learners were busy listening, writing, and answering questions, he thought disciplinary problems such as making a noise when teaching, and disturbing other learners were reduced. Learners were engaged in teaching and learning all the time.

Both teachers pointed out that time was a challenge to them to do other activities which are part of the topic. T1 narrated that they are in a rural area, so other forms of teaching strategies such as using information and technological devices was a challenge. I would say that there were some best practices and missed opportunities from both teachers in their lessons. They concluded that they were happy to do research with me. In summary the themes which emerged from stimulated recall interviews and reflections are stipulated in the table below.

Table 5.1: Themes and sub-themes that emerged from stimulated-recall interviews and reflections with relevant literature

Themes and sub-themes	**Relevant Literature**
Views/feelings about lessons taught of the topic chemical changes -interest, enjoyment -motivation - planning - Organisation - engagement of the learners	Killen (2015), Göker (2016), Lane et al. (2014)
Missed opportunities on teaching strategies of the topic chemical changes -practical activities - additional teaching resources -time management	Mavhunga & Rollnick (2013), Chikamori et al. (2013), Macmillan & Schumacher (2014)

5.2.1 Views/feelings about lessons taught of the topic chemical changes

These teachers watched their lessons individually and I asked guiding questions on how they viewed their lessons. Both teachers were excited to see themselves in the videos. T1 commented that if learners could watch and see themselves in the videos, it could be a sort of motivation for them to participate and every child would be able to at least say something in class. T2 also shared the same sentiments that he never expected to see himself in action like that with his learners. He further explained that he enjoyed his lessons since he has not been with the learners face-to-face for a long time. He was motivated to stay focused and keep the learners' attention on him. Furthermore, T2 also reflected that since he planned his lessons' activities, he was confident and comfortable during the mediation.

These teachers pointed out that through watching videos it could possibly change the attitudes of learners in class and the presentation of lessons from the teachers. Both teachers pointed out their strengths, weaknesses, and the level of participation from the learners, as Lane et al. (2014)

point out, that reflections provide teachers with an opportunity to learn from their own teaching experience and identify gaps. In agreement with Lane et al. (2014), Killen (2015) also articulates that teachers' reflections consolidate their learning by identifying their weaknesses and how to improve on them.

T1 illustrated that his learners did not participate fully in the lessons as their understanding was taking more time. The teachers emphasised that next time they would try their best to engage the learners in the lessons. They would try other pedagogical methods, as Göker (2016) illustrates that reflections create an awareness in which teachers evaluate their teaching methods which might possibly help them to change their teaching practices. On the research process, T1 mentioned that it was an eye opener to him. It gave him a feeling of being prepared, organised, and not wasting time doing other things but being fully engaged in teaching and learning. He realised that planning for a lesson requires a teacher to familiarise themselves with the concepts and content of the topic. Not mastering the content and concepts might lead to poor presentation of material. T2 also commented that the research process was an encouragement to him and he identified some of the different ways of mediating learning in science lessons. He was so happy to see a colleague observing his lessons and capturing videos. He acknowledged that some competencies of the topic of chemical changes cannot be made understandable to the learners in one day but they needed to be constantly re-emphasised.

5.2.2 Missed opportunities on teaching strategies

These teachers articulated that there were some missed opportunities in their lessons after watching the videos. Chikamori et al. (2013) articulate that through reflections, teachers can explore ways on how to improve lessons based on preparation, resources to be used, and how they will be presented. Both teachers pointed out that their mediation was dominated by teacher talk. They did not apply the learner centred approach and missed the opportunity for learners to have hands-on practical activities. T2 also noted that even though he brought some easily accessible materials and learners did some observations, he did not give them chance to do it themselves with his guidance.

These teachers accepted that practical activities are an important part of their lessons. Furthermore, they added that some concepts which were partially perceived could be strengthened. They also added that they have to manage their time effectively as it will always be a challenge. Next time, T1 alluded that he would come up with more concrete easily accessible

materials as he lacked that part in his lessons. Meanwhile, T2 indicated that he would allow learners to have discussions, share ideas, and do presentations as he explained in the semi-structured interviews. He has to identify learners who are not so active to have dialogues with them. Both teachers pointed out that next time they would include pictures and draw diagrams to enhance the different kinds of mediating tools and support the teaching strategies. As a result, these teachers realised the significance of improving their mediating tools in the mediation of learning and teaching strategies (Mavhunga & Rollnick, 2013). It is through reflections that these teachers could assess their own teaching as McMillan and Schumacher (2014) point out that reflections are a learning experience where teachers analyse their own lessons and strengthen them. Through these reflections these teachers learnt that planning is crucial and learning is a process.

5.3 Chapter Summary

This chapter presented data from stimulated recall interviews and teachers' reflections. This was aimed at answering research question three. During this process, it was reviewed that teachers were excited to watch themselves on video and analyse how they engaged with learners in teaching and learning. They could easily point out their strengths and weaknesses and opportunities for improvement. They regarded reflection as a significant activity which informed them about their teaching practices. Moreover, through watching their video lessons, they acknowledged that using everyday experiences and easily accessible materials enables learners to understand the science around them better. Reflections enabled these teachers to identify gaps in their lessons. In the next chapter, I now present the summary of findings, recommendations, areas for future research, personal reflections and conclusions.

CHAPTER SIX: SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

The goal of this study was to explore how grade 9 Physical Science teachers mediate learning of the topic of chemical changes. The study was triggered by the National Examiners' reports and my teaching experience of Physical Science in grade 9. Through the process of conducting this research study, I gained some useful insights on teachers' perspectives, experiences, and pedagogical insights, how they mediated learning, and their views on reflections on the topic of chemical changes. Moreover, reflections also provided me with deeper understanding on the mediation of learning on the topic. Through doing this research and with the guidance of my supervisor, my research skills have improved. Additionally, I also improved on my computer skills.

The study was a qualitative case study and socio-cultural theory (Vygotsky, 1978) was adopted as the theoretical framework of the study. I used semi-structured interviews, lesson observations, stimulated recall interviews, and teachers' reflections to generate the data. Data were analysed using a thematic approach and discussions were made using relevant literature. Furthermore, Atallah et al.'s (2010) indicators were used to identify perspectives and experiences while pedagogical content knowledge from Shulman (1986, 1987) with particular focus on TSPCK from Mavhunga and Rollnick (2013) was used as a lens to analyse the data.

In this chapter, I start by presenting findings from my research questions, followed by the recommendations, limitations of study, and areas of future research. Thereafter, conclusions will be drawn from the study followed by personal reflections.

6.2 Summary of Findings

What are grade 9 Physical Science teachers' perspectives, experiences, and pedagogical insights regarding mediating learning of the topic of chemical changes?

In response to the first research question above, it emerged that the topic of chemical changes might need to integrate many examples to mediate it. The teachers registered that the topic deals with what is happening in our everyday experiences and there are a variety of resources to be used. The findings revealed that it is a topic which does not only rely on textbooks but learners' experiences, local knowledge, and affordable materials. It emerged that when mediating learning certain attitudes such as interest, enjoyment, value, and confidence are important to be considered. This can be achieved by relating the science in the classroom and outside the classroom, as stated by Aikenhead and Jegede (1999) that there must be a border crossing between school science and experiences from home. These teachers acknowledged that the use of everyday experiences are influential in mediating the topic of chemical changes.

Moreover, these teachers reviewed that there are a lot of practical activities which can be conducted regarding the topic whereby learners can have 'hands on' and 'minds on' experiences as stipulated by Asheela et al. (2021). They indicated that practical activities are performed to strengthen the theoretical content which is explained in the classroom. Thus, Etiubon and Udoh (2017) explain that science lessons require practical activities which broaden the experiences of learners for meaningful learning to take place. However, the teachers revealed that there are a number of limitations which they normally experience such as limited laboratories and appropriate classrooms to carry out practical activities, lack of chemicals and equipment, and limited time. These challenges also emerged from Asheela et al.'s (2021) study as challenges associated in conducting practical activities in science lessons.

How do grade 9 Physical Science teachers mediate learning of the topic of chemical changes?

During lesson observations, it was revealed that, teachers have sufficient PCK of the topic chemical changes. The demonstrations, question and answer method and easily accessible materials used during mediation were guided by PCK. The PCK guided teachers to mediate the suitable content to the learners. The knowledge areas of TSPCK which emerged from observations are learners' prior knowledge, curricular saliency, what is difficult to teach, representations, and conceptual teaching strategies. These TSPCK areas are explained below.

Learner's prior knowledge – These teachers had a common way of eliciting learners' prior knowledge through questions and answers and referring to what learners learnt previously. They probed learners through questions as to find out the level of understanding of the topic. As evident from the lesson preparations, teachers did not include possible pre-conceptions which learners could have regarding the topic. Instead, the teachers assumed that learners would recall what was taught from the previous grades. It turned out that the prior knowledge which learners were supposed to have was limited. The teachers ended up giving learners leading questions. Through questions and answers, it was observed that integration of prior knowledge throughout the lessons was limited. Yet, Roschelle (1995) avers that prior knowledge should be integrated during teaching and learning for meaningful learning to take place.

Curricular saliency – These teachers made some concerted efforts to identify the main ideas of the topic of chemical changes. However, it was observed that concepts which were introduced were not clearly shown how they were related to the topic chemical changes. As a result, learners could not see most of the links. It is important for teachers to identify concepts before mediating the intended topic (Chani et al., 2018). Moreover, it is significant to consider the interrelatedness between the concepts and main ideas. It might enable learners to see the sequence, understand what is being taught, and what is expected from them to be taught later (Mavhunga & Rollnick, 2013). There is a need for teachers to be supported on knowledge of curriculum saliency as proposed by Mavhunga et al. (2016).

What is difficult to teach – It was observed that teachers mediated learning without identifying concepts which pose a challenge to the learners. Mediation was done mostly through explanations and questions which I feel was not enough to determine the level of understanding on what was taught. All learners did not have an opportunity to answer to the questions during mediation. As T1 reflected that concepts such as exothermic, endothermic, reactant, and product were not being understood by learners because they failed to give complete answers when asked.

Representations – This TSPCK is about how teachers explained science concepts using different types of mediation styles. Even though teachers made some efforts to explain concepts by asking questions, diagrams, pictures, and charts were not used to strengthen their explanations. There was also a lack of hands-on practical activities, as Asheela et al. (2021) describes that hands-on practical activities motivate learners to learn science concepts better.

Conceptual teaching strategies – These are the strategies which teachers used to mediate learning. They applied the use of easily accessible materials and language as mediation tools in teaching and learning. However, it was observed that there was limited understanding of how to use easily accessible materials to mediate learning. T1 used examples within the classroom such as opening the window, opening the door, and burning a paper which were failed to support his explanations. Moreover, T2 brought in some concrete materials, examples within the classroom, and a practical demonstration for learners to observe. It was observed that T2 had knowledge on easily accessible materials for learners to at least understand the topic of chemical changes.

The study reviewed that even though the teachers were aware of practical activities to be integrated on the topic of chemical changes. T2 performed a practical activity when he used sodium hydrogen carbonate with hydrochloric acid and aluminium foil with hydrochloric acid. However, he did not give the learners the opportunity to Predict-Explain-Explore-Observe-Explain (PEEOE) as proposed by Asheela et al. (2021). This approach keeps learners busy and stimulates the thinking so that they understand the concepts better (Okoye, 2013). This was a missed opportunity of practical activity and explanatory tasks which left a gap for the learners in terms of hands-on and minds-on practical activities.

The two teachers made successful use of language through their explanations and demonstrations. Teacher-learner interactions were limited as they did not engage learners to learn through a variety of interactions. This might be due to the fact that these teachers practiced more of traditional method than a learner centred way of teaching. The teachers talked more than the learners which opposed the suggestion of Lemke (2001) that learners should be given more opportunity to talk for them to develop the language of science. Furthermore, Lemke (2001) posits that teachers and learners need a balance of interactions and talking time. Furthermore, if learners do not talk frequently during teaching and learning, it might affect the conceptual teaching strategies of the teacher (Mavhunga et al., 2016).

What lessons appear from teachers' reflections after mediation of learning of the topic chemical changes?

Reflections provided teachers with an opportunity to express their views about the lessons they taught. This was done by looking at the activities used, the teaching methods, learners' participation, and components which were part of the teaching and learning. In this study, teachers did reflections through watching their videotaped lessons. They expressed their views

as they watched their lessons. They were so thrilled to see themselves in those videos together with the learners. Through watching these videos, the study was in adherence with Vygotsky's (1978) socio-cultural theory, together with the concept of social interactions, as participants were sharing their views with me. The reflective space allowed them to share their views and experiences by pointing out their strengths, learners' participation, and where to improve next time. They expressed that through watching videos, made them to be aware of their own teaching practices. It showed them where lessons could possibly be strengthened and identified other teaching resources to use when teaching the topic. They mentioned that it is a good practice to emulate which can be done through writing in order to create awareness. They were strongly motivated after watching their video lessons

6.3 Recommendations

The study focused on how teachers mediated learning of the topic of chemical changes. Teachers are also encouraged to compile a list of pre-concepts of science topics before mediating learning. It might help them to identify concepts which were not properly understood. They are also encouraged to be innovative to develop learning materials as to assist learners to understand the topic of chemical changes and other science related topics. They should include various types of hands-on practical activities so that learners can observe and explore more science related concepts. Since the Physical Science syllabus is not explicit on the use of easily accessible materials, I recommend that advisory services should identify teachers in schools who are more knowledgeable on the use of easily accessible materials so that teachers are exposed to such materials.

The use of easily accessible materials enables learners to realise the value and relevance of science in everyday situations. By promoting the use of a variety of teaching resources, it might reduce the traditional methods of teaching and promote learner centred teaching so that learners construct meaning and understanding through interactions (Vygotsky, 1978). Reflections should also be practiced by teachers all the time because it offers an opportunity to critique their lessons.

6.4 Limitations of Study

Due to the fact that only two teachers were involved in this study, the study depicts a small sample size meaning that the findings from the study cannot be generalised. However, the study provided me with an opportunity to gain some insights on the views and experiences of teachers,

how they mediated learning, and their reflected views on lessons taught. Furthermore, the focus of the study was on teachers and leaving out the learners who are central to learning means that some of the underlying issues regarding the mediation of learning on the topic of chemical changes could have been missed.

6.5 Areas of Future Research

This study opens up some opportunities for future research which might be:

- Learners' views, attitudes, and experiences regarding the topic of chemical changes.
- The role of practical work when mediating the topic of chemical changes.
- How teachers' professional learning communities (CPD) influence or not the mediation of learning of the topic of chemical changes.
- The influence of using easily accessible materials on learners' performance when mediating the topic of chemical changes.
- Exploring the use of technological devices as teaching resources and if they influence or not the understanding of learners on the topic of chemical changes.

6.6 Personal Reflections

This research journey started when I was doing my final BEd Honours degree with Rhodes University. When I entered the university, I was introduced to three main themes, namely, prior knowledge, indigenous knowledge, and language in science education in relation to how they play a role in teaching and learning of science. The assignments which were done in the BEd Honours were subsequently based on those three themes and it was an interesting and exciting journey as I was applying them in my own teaching classroom, identifying my weaknesses and strengths, and identifying some opportunities for improvement. By the end of the BEd Honours course, I saw myself growing in terms of pedagogical practices while integrating prior knowledge and indigenous knowledge. I doubted at that time if I could pursue a master's degree due to studying part time, working, and not being there for my family.

The encouragement which I got from my supervisors, Prof Kenneth Ngcoza and Dr Zukiswa Nhase and my friend Sabina who was my roommate at that time made me to apply and embark on my journey of a master's degree. In March 2019, we were invited to the research design course at Rhodes University. The course was an eye-opener to me as I found it helpful and it

strengthened my understanding on the research process. The experienced scholars and supervisors who gave their presentations on the research design course were so open that they shared how they came up with their proposals and how they managed to complete their research studies. That motivated me as I imagined myself giving similar presentations like them.

After the research design course, I started perusing the Namibian curriculum document, the textbooks used, and the examiners' reports. As I was reading through, I decided to expand and modify my research topic which I had developed from the mini research proposal in BEd Honours. Thereafter, the topic was refined, but my supervisors kept on reminding me that topics should not be married they keep on changing which I eventually realised was really true. Before the whole research process has to begin the requirement of Rhodes University is to apply for ethical clearance. I found this process frustrating as I had to fill in ethical forms and re-do them several times before the proposal was approved. It gave me sleepless nights but on a positive note, it gave me courage and determination. At last my proposal was approved and I took it as a learning curve that obstacles are part of life and they give an opportunity to achieve what you are hoping for. The ethical process motivated me to double my efforts as I started to expand on my literature and methodology sections.

As I started preparing my data generation tools and made some appointments with my participants, a huge, unexpected challenge emerged, the outbreak of the Coronavirus (COVID-19). Namibia recorded its first cases in March 2020 and this led to the closure of schools. This was a disappointment to me but then it was inevitable, as I understood how dangerous it was and its impact on society. But all in all my supervisors were there, and provided guidance on modifying the literature and methodology parts. During this time of the pandemic, as teachers we explored different methods on how to reach out to learners so that teaching and learning continued. The Ministry of Education introduced a new strategy which they termed 'learning from home'. Teachers were directed to create platforms such as WhatsApp groups, recording lessons and sending them to the learners and preparing booklets with notes and activities for learners to learn from home. However, these types of teaching practices required learners to have laptops, smartphones, Wi-Fi, and data which disadvantaged most learners from rural areas and challenged backgrounds.

As there were decreasing numbers of confirmed cases in the country, the Ministry of Education introduced a mechanism of opening schools in phases. I kept on communicating with my

participants and rescheduled the appointments after three months of not having face-to-face contact with learners. My participants did not have a problem in giving me new appointment dates. I started with semi-structured interviews, lesson observations, stimulated recall interviews, and a platform for reflections. I was so patient and determined to follow all the research processes as explained in the methodology so that my study could be validated. Thank you to my kind and caring supervisors, Prof. Kenneth Ngcoza and Dr Zukiswa Nhase, MEd master's group and my husband, as I could not make it on my own without their moral support. It was not an easy journey but I am happy to say it out loud that togetherness can make you go far.

6.7 Conclusions

The findings from this study concluded that learners' experiences, using everyday examples and easily accessible resources play a great role in mediating the topic of chemical changes. The attitudes of teachers should be motivating and encouraging so that learners will be interested in the lessons and be active participants. Moreover, the study reviewed that teachers still practice traditional methods of pedagogy rather than a learner centred approach which has been emphasised in teaching and learning. Curricular saliency, knowledge of resources, and conceptual teaching strategies still need to be strengthened among teachers. Reflections also played an important role in analysing the lessons. Thus, the study suggests that there is a need for professional development platforms in schools. These platforms might help teachers to share their expert knowledge and strengthen their PCK and be consistent in their pedagogical practices. Meanwhile, the centre and main point of teaching and learning is for a learner to understand and interpret the world of science.

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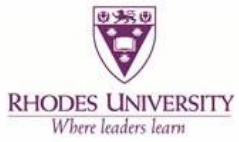
APPENDICES

Appendix A: Approval Letter from Ethics Committee



Human Ethics subcommittee
Rhodes University Ethical Standards Committee
PO Box 94, Grahamstown, 6140, South Africa
t: +27 (0) 46 603 8055
f: +27 (0) 46 603 8822
e: ethics-committee@ru.ac.za

www.ru.ac.za/research/research/ethics
NHREC Registration no. REC-241114-045

28 May 2020
Orrice Likando
Email: g17l8173@campus.ru.ac.za
Review Reference: 2020-1155-3439

Dear Ms. Likando

Title: Exploring how grade 9 Physical Science teachers mediate learning of the topic of chemical changes.

Principal Investigator: Prof Kenneth Ngcoza

Collaborators: Ms. Orrice Likando,

This letter confirms that the above research proposal has been reviewed and **APPROVED** by the Rhodes University Ethical Standards Committee (RUESC) – Human Ethics (HE) sub-committee.

Approval has been granted for 1 year. An annual progress report will be required in order to renew approval for an additional period. You will receive an email notifying when the annual report is due.

Please ensure that the ethical standards committee is notified should any substantive change(s) be made, for whatever reason, during the research process. This includes changes in investigators. Please also ensure that a brief report is submitted to the ethics committee on the completion of the research. The purpose of this report is to indicate whether the research was conducted successfully, if any aspects could not be completed, or if any problems arose that the ethical standards committee should be aware of. If a thesis or dissertation arising from this research is submitted to the library's electronic theses and dissertations (ETD) repository, please notify the committee of the date of submission and/or any reference or cataloguing number allocated. Sincerely,

Prof Arthur Webb

Chair: Human Ethics Sub-Committee, RUESC- HE

Appendix B: Approval letter from the Regional Director

REPUBLIC OF NAMIBIA

OTJOZONDJUPA REGIONAL COUNCIL

DIRECTORATE OF EDUCATION, ARTS AND CULTURE

Tel no: 264 67 308000
Fax no: 264 67 304871
Enq: J. Sikeso
Email: jsikes005@gmail.com

Private Bag 2618
Erf 280, Sonweg Street
OTJIWARONGO
Namibia

26th May 2020

File No: 14/6/10

[redacted]
GROOTFONTEIN

Namibia

Dear Ms. Likando

SUBJECT: EXPLORING HOW GRADE 9 PHYSICAL SCIENCE TEACHERS MEDITATE LEARNING OF THE TOPIC OF CHEMICAL CHANGES IN THE OTJOZONDJUPA REGION

Your letter dated 28th April 2020 bears reference and is hereby acknowledged.

Regarding the above mentioned subject, the Directorate of Education, Arts and Culture is pleased to inform you that permission is granted as per your request to conduct research at schools in the region. The School Principals and Inspectors of Education will be notified of the approval by copy of this letter.

You are kindly requested to make sure that the programme to be conducted at schools should by no means whatsoever disrupt teaching and learning. We hope and trust that this exercise will enhance quality education in the region. Your cooperation in this regard will be highly appreciated.

Yours faithfully

OTJOZONDJUPA REGIONAL COUNCIL
DIRECTORATE OF EDUCATION
OFFICE OF DIRECTOR
2020 -05- 26
TEL: 067-308000 PRIVATE BAG 2618
FAX: 067-304871 OTJIWARONGO
OTJOZONDJUPA REGION

MS. J.M. MUTENDA
REGIONAL DIRECTOR

Appendix C: Letter to School Principals

O.M. Likando
P.O Box 1054
Grootfontein

The Principal
X Secondary School

Dear Sir / Madam

Re: Request for permission and access to conduct Educational Research at your school

I am Orrice Likando, a part- time master's student in education at Rhodes University, student number (17L8173). I am currently employed at Coblenz Combined School, teaching Physical Science grade 8-9, Physics 10-11 and Chemistry 10-11. I am humbly requesting for your permission to conduct a research study at your school.

My topic is: Exploring how grade 9 Physical Science teachers mediate learning on the topic of chemical changes.

Examiner's reports have shown that learners are scoring poor marks on the questions regarding chemical changes. This might be caused by certain issues which need to be explored. For this reason, this research intends to explore how teachers mediate learning on the above mentioned topic. The findings which will emerge from this research study might possibly inform teachers on certain teaching practices and possibly improve practice. The study will be under the supervision of Prof K. Ngcoza (k.ngcoza@ru.ac.za) and Dr. Zuki Nhase (nhasez@ufs.ac.za). My contact details are +264812203628 and email (g17L8173@campus.ru.ac.za) . Should you have any concerns, feel free to contact my supervisors and Mr. Siyanda Manqele the ethics coordinator at (ethics-committee@ru.ac.za) at any time.

I would like to ensure your office that should I be granted permission to carry out the research, research ethics will be applied at all times. The identity of the school and participants will be treated with a high degree of confidentiality and anonymity.

Your humble understanding will be very much appreciated.

Yours faithfully

Likando O. M

Appendix D: Letter to the Participants

Likando O. M

P.O Box 1054

Grootfontein

X Combined School

Grootfontein Circuit

Dear Participant

Re: Participation in the research study on the topic of chemical changes

I am Orrice M Likando , a student at Rhodes University, student number (17L8173), doing a Master's Degree in Science Education. Currently busy with research studies focusing on the topic of **Exploring how grade 9 Physical Science teachers mediate learning on the topic of chemical changes.**

The study will include interviews, lesson observations with video recordings and stimulated recall interviews. You will be asked to teach lessons on the topic of chemical changes, and be the centre of mediating learning., Participation will be voluntary, you can withdraw at any time you wish, and the data gathered will only be used for the purpose of the study.

The study will be under the supervision of Prof K. Ngcoza (k.ngcoza@ru.ac.za) and Dr Zuki Nhase (nhasez@ufs.ac.za). My contact details are 0812203628 and email (g17L8173@campus.ru.ac.za). Should you have any concerns feel free to contact me, my supervisors and Mr. Siyanda Manqele the ethics coordinator at (ethics-committee@ru.ac.za) at any time.

I humbly request you to read the consent and sign the declaration attached below.

Best regards

Likando. O. M

CONSENT

I am aware that

- I will be the participant for the above mentioned topic.
- I am willing to be interviewed and make time for it.
- I am free to withdraw at any time I may wish without negative or undesirable consequences.
- The information provided will be used only in the research project.
- I am also aware that the information provided by me will be strictly confidential and the findings will be reviewed in the research thesis.
- My identity in this study will be protected with the code of ethics stipulated by Rhodes University.

Having taken note of the above information, I freely and volunteer to take part in the research process and acknowledge that I have not been forced to do so.

Declaration

I……. (full name and surname of participant) hereby confirm that I understand the contents of this letter and the nature of the research project. I consent to participate in the research project.

Signature of participant ……. Date…….

Appendix E: Letter to the Parents

O.M. Likando

P.O Box 1054

Grootfontein

Dear parent / Guardian

Re: Request for your child to participate in the educational research.

I am Orrice Likando M, a part time student at Rhodes University with student number (17L8173). I have written a letter to the principal where your child is attending school to seek for permission to conduct an educational research. The focus of the research is to explore how grade 9 Physical Science teachers mediate learning on the topic of chemical changes. Should I be granted permission, I will be doing some video recordings of lesson presentations in which your child might appear. Therefore, I would like to seek permission from you to know if your child can take part in this educational research.

The research study will be under the supervision of Prof K. Ngcoza (k.ngcoza@ru.ac.za) and Ms. Zuki Nhase (nhasez@ufs.ac.za) . My contact details are +264812203628 and email (g17L8173@campus.ru.ac.za). Should you have any concerns feel free to contact me, my supervisors and Mr. Siyanda Manqele the ethics coordinator at (ethics-committee@ru.ac.za) at any time.

I undertake to work with your child ethically and he/she will be free to choose whether to be part of this educational research or not.

Yours faithfully.

O. M. Likando

If you would give permission for your child to be part of this research study, please complete the declaration below.

I…… (full name of parent/ guardian) hereby confirm that I understand the content of the letter and give permission for my child to participate in the educational research.

…… ……

Signature of parent Date

…… ……..

Signature of learner Date

Appendix F: Semi-structured interview

Question	Purpose
1. May you kindly tell me your views and experiences when teaching the topic of chemical changes?	Find out teacher's attitudes and experiences on the topic of chemical changes.
2.Could you please tell me how you introduce the topic of chemical changes?	To find out teacher's abilities, thoughts and teaching approaches.
3.What do you think are the enablers and shortcomings when teaching the topic of chemical changes?	To find out the nature of the topic of chemical changes.
4. What do you do to make learners understand what you teach?	Understand what type of instructions and activities are provided to the learners.
5. How do you know that what you have taught, learners have understood?	To find out what type of evidence proves that learning took place.

Adapted from Ayla Cetin-Dindar and Omer Geban (2017, p. 89)

Appendix G: Interview Script 1 Teacher 1

Ti: Good morning my [redacted]

T1SSI: good morning Ms.

Ti: thank you for having this time with me which you allowed to have with me. I really appreciate it very much.

T1SSI: you almost welcome Ms. I do think that this research will help us all.

Ti: Okay to start with, may you kindly tell me about your experiences and views when you are teaching the topic chemical changes.

T1SSI: I did not get the question well. Can you try to ask it another way round?

Ti: In your years of teaching, what did you observe or learn when you normally teach the topic chemical changes?

T1SSI: Yaa, its actually an important topic and very useful. It is only that learners in grade 9 regard it as if it is a new topic which they did not do from the previous grades. Grade 9 learners most of them are not familiar with the topic chemical changes. That is where learners their participation is passive and out of topic showing that they are not coping with the topic. But the topic that is, it deals with every day experiences which form part of the topic. But from my own observations learners are not coming out to the topic, even today I could see that learners are not really aware of those chemical changes at home.

Ti: So what should be done for learners to be aware of these daily life experiences which can be part of the topic chemical changes.

T1SSI: Well aaa, what is important for us as teachers is to know the environment where learners come from. Then from there on the topic chemical changes we can include examples such as cooking, painting houses, erecting fences since children from these households they are coming from fence homestead both from wood fences and wire fences. Also using firewood to cook and many others which are found within where they stay can be used once they come to know what a chemical change is all about. Once they know the type I think even the participation can increase in class.

Ti: is that all?

T1SSI: Yes, Yes Ms.

Ti, Okay we can proceed with our questions. Could you please tell me how do you normally introduce the topic chemical changes?

T1SSI: Yaaa... mmmm normally I would eeee in actual fact, I will start by doing, doing some actions in class or by doing an activity for example like tearing a paper moving a desk, opening the window things like that and then learners will normally or try to identify what I am doing and is what is exactly is happening there. Then after that, I will also ask them to come up with their own examples regarding the changes which they know are physical. So I think that is how I introduce the topic. They first have to know the physical change before I move to chemical change.

Ti: Alright, can we move forward with another question?

T1SSI: Yes Ms.

Ti: What are the enablers and constrains /short comings when you are teaching the topic chemical changes.

T1SSI: Aaa…mmm… okay since it is a topic with everyday examples, there are a lot of examples which can be used to enable teaching the topic chemical changes. You can bring what is affordable and accessible around and within the environment. There are a lot of practical activities and experiments which can be done towards enabling the topic. Learners also have some of the experiences regarding the topic. Some of these experiences come from home and we can be able to bring out those experiences. But unfortunately our situations in our schools does not allow us to do some of the experiments and investigations as it is time consuming and we have to complete our work for the term on time. As I am speaking, we don't have appropriate instruments and equipment's even to show some videos to the learners. For example, the kettle in which I tried to boil the water just to realise that the plugs are not working. The environment where we are living does not allow us to explore IT methods of teaching and using learners' experiences also waste a lot of time. The school basically is under resourced, so teachers has to make plans to enable the topic to the learners.

Ti: Thank you for all those explanations and clarities. The next question is that how do you make learners understand what you teach them.

T1SSI: Yaa…aaa. So eee the way I make learners understand is simply to try and use practical work which I sometimes hardly do. Every day experiences which I normally give will explain some of the things for learners to understand. Like a learners gave an example of frying an egg as chemical change, so I have to look at other activities because not all of them are frying eggs at home. So I do other activities whereby the learners they can see in class within the environment which are easily accessible like opening a window, burning a paper, opening a door, the type of little things which I can exercise to check if learners they do understand.

Ti: Okay, can I proceed with the next question, how do you know that what you have taught, learners understand.

T1SSI: I normally work more on learner centered way. Where I normally try to ask questions after a certain topic is completed and I give a task. I also use questioning and answering method during teaching and learning. When I ask learners few, few questions and if the answers are not satisfactory I move back and repeat myself and assess them again through these questions and answers. After elaborating again, I give a short class activity and then ask them individually to see if they achieved the competencies for the lesson before I move forward. And then I bring in available and affordable materials like burning a candle, at least fire is burning they can see. Then they can relate what they see in class and what is within the environment, maybe bringing in those everyday experiences might help learners to understand for me to know also if they understand. After completing the topic. I don't wait I test them immediately so that I know how should I move forward. You could see when I was asking learners whether opening a door is physical or chemical changes. The learners said chemical change. You could see already that the learner did not follow up the teaching and learning.

Ti; Thank you for having this time with me in this challenging time of COVID-19, I do appreciate it.

T1SSI: You're welcome Ms.

Ti: Thank you.

Appendix H: Interview Script 2 Teacher 2

Ti: Good afternoon [redacted]

T2SSI: Good afternoon [redacted]

Ti: Thank you for availing your time to come and conduct this interview with me. I really appreciate it very much. Feel free to answer to any questions and ask if you did not understand the question well. This is an educational research which will benefit both of us.

T2SSI: Yebo, aaa, you are more than welcome any time.

Ti: Alright, I have few questions regarding how we teachers mediate learning of the topic chemical changes to the grade 9 learners.

T2SSI: It is fine, I will try to answer from what I know and experienced.

Ti: Ok to start with, may you kindly tell me about your views and experiences when mediating the topic chemical changes.

T2SSI. What is mediation?

Ti: Mediation is another word for teaching. May you tell me your views and experiences when teaching the topic chemical changes.

T2SSI: Okay Ms. [redacted], thank you so much aaammm, with me every time and then when I conduct lessons on the topic chemical changes, in my own capacity chemical changes is an enjoyable topic because it is definitely one pf the practical topics that I can definitely do with my learners. It is one of the most interesting topic and it is not much challenging to teach like any other topics as you teach. Why so, it is because aaa within the topic itself, you have lot of examples of practical's that you can do of which learners can aaaa carry out without an investment of money or fund to buy anything. Definitely, it might only depend on natural resources that are available within the area itself. So to me it is one of my favourite topics for now.

Ti: Al right, can we proceed with our questions?

T2SSI: Yes, Yess

Ti: Could you please tell me, how do you normally introduce the topic chemical changes to your grade 9 learners.

T2SSI: Well, we have different ways, but aaaa with eee changes usually, in most cases, I would sometimes bring in aaa mmm, a match stick, then with pieces of paper or sometimes I bring a piece of wood which is burnt, and then I bring in some little ash. You ask learners what is their experience from home when they look at the two different objects. If not that is when you can definitely, you can also engage and imply one of the upper introductions like you ask learners to think back maybe let's say the way the environment was in the past compared to now. What differences are there and those differences you ask learners if they are permanent or they are not, are they like still as they were before or how. As they engage in engage in that discuss, definitely you will be able to site some of the chemical changes that are occurring within the area itself. And from that, you can pick the point out and then tell the learners exactly what chemical changes is all about.

Ti: Alright, I see. Mmmm can we proceed to the next question

T2SSI: Yes, I think your questions are clear in a simple language.

Ti: My question this time is that, what do you think are the enablers and short comings when you are teaching the topic chemical changes.

T2SSI: aaaa thank you for the question aaa mmm the question is quiet good mmm if you look at the, what are enables me to be effectively deliver content about chemical changes to the learners, aaa mmm its about sorry for that….

Ti: its okay…. You can continue

T2SSI: eeee the content itself it does not really require much from the teachers, it's the learners who should think critically. It's simply based much on practical's and the use of available resources. It is definitely based on practical's. And maybe on the other hand, you would talk of the short comings like, you would find some learners, since it's a practical topic, you would find some learners those who are not practically oriented to carry out experiments and so forth. You have to definitely find a way to engage these learners and make them get that interest to be involved to be in the carrying out of experiment and practical's and everything else. And especially there are some learners that you would find in class whereby those learners they are

anti-social or maybe they are not so good in socializing, mingling with other learners. They would always sideline themselves. So to bring them into the lesson if it is more like based on practical, it is one of the most challenging aspect we have but all in all its only that I could say about.

Ti: If I may ask, do you normally perform practical activities in the classrooms.

T2SSI: Ammm sometimes we do practical tasks and activities in the lessons and experiments yes but, then there are challenges I normally experience regarding practical activities. It is that of eee sometimes the environment doesn't allow to perform some of the practical activities. For example, let me say for instance maybe you are conducting a combustion reaction which involves burning and then you end up having maybe those learners are asthmatic aaaa and then you have to take them outside and then they might miss some things out. On the other hand, it is time consuming and then you end up like sometimes a 40minute period it won't be enough to carry out the whole experiment at hand so usually when we have such situations we make it like two periods lesson whereby the first lesson it goes for theoretical learning and then the next one is only used for practical's. So that way at least we are going to be there.

Ti: Okay…aaa... how do you make learners understand what you teach?

T2SSI: Pardon me

Ti …Aaa how do you make learners understand what you teach regarding the topic chemical changes?

T2SSI: Well, aaaa mmmm, its really quiet challenging sometimes, because in most cases learners are on different levels, some would understand from the theoretical teaching, some they would definitely need that part of, of practical's and other staff. So for you to be able to make them understand, you have to use at least to more than one method of teaching. The teaching which at least will involve all learners and to cater for all the learners like for example, if I am to carry out, if I am to conducting a lesson about chemical changes, you would realise that there are some learners who might understand the first part, just when you introduce as you are explaining and all that, but there are some learners who will definitely won't. So I do much of aaa learner centered and ee learners have to be 100% involved within the lesson. And then that is maybe through questions and answers and sometimes in most cases we do now hands on task whereby

the learners they have to do a lot of practical's, they have to experience things, they have to see things happening they have to all in all, I would say they should carry out observations. So at least by that way you are, will be totally convinced that definitely not all my learners they are totally definitely understood. But for me to be able to know that everything is okay my learners understand the topic of the lesson, I usually use aaa sometimes to be questions and answers after the lesson or sometimes I give a class activity or sometimes I give them a homework, I would give them an investigation any of that for as long as it can measure the level of their understanding regarding the topic itself sooo that's all.

Ti: mmm okay, thank you for explaining all that, we will be almost done with our questions. May I continue with the remaining questions?

T2SSI: Oh yes you can proceed.

Ti: Alright, how do you tell that what you have taught learners understand the content of the lesson.

T2SSI: Good question, aaaaammm in that case like I mentioned earlier, sometimes I conduct a dialogue with learners, talking to them if they understood the lesson. I would ask learners sometimes to be in form of groups or sometimes they sit in pairs, they will have a set of questions based on the specific competencies that they would be asking one another and then as they present to the class in my presence and the presence of all learners. Definitely, it will measure how the understanding of the learners but that is not reliable because it is a little bit partial. So what you do you will bring back to the written work where they have to carry out some tasks. Either it is homework, classwork, or test or sometimes an investigation or even use what comes back to you on those tasks. It will be able to measure the level of understanding eee regarding the topic itself. Soo in that case usually it works out. But not only that sometimes I would send learners outside where they have to carry out observations within the environment and then it might be for a day or two or a week, maximum sometimes just a week. For what purpose, it's for them at least to observe some changes that they can classify as chemical changes which they can bring to class and report as feedback and these eeee in that case you shall then learners learn from each other. If that happens I shall be satisfied that my learners have quietly understand the topic.

Ti: Okay we have come to the end of this interview and I would say thank you for providing me with this opportunity. In this situation where we are of the COVID-19 and you were still willing to do these interviews.

T2SSI: You are welcome because I believe that doing research will allow us to improve for the future. I will have all the time whenever you need my participation willingly.

Ti: Thank you so much.

T2SSI: Any time you are always welcome.

Ti: Thank you

Appendix I: Collated Responses from semi-structured interviews

Thematic Approach; Sub-themes and colour codes

Turquoise: ……. Teacher's views and attitudes towards the topic chemical changes
Green ……. Teacher's experiences and pedagogical insights on learners' social context
Yellow …….Teacher's pedagogical insights on introducing the topic chemical changes
Red ……. Teacher's experiences on challenges of the topic chemical changes
Dark yellow ……. Teacher's views and experiences on hands on practical activities
Pink ……. Teacher's views and experiences on learners understanding of the topic chemical changes

1. May you kindly tell me your views and experiences when teaching the topic chemical changes?

T1SSI: Yaa, its actually an important topic and very useful. It is only that learners in grade 9 regard it as if it is a new topic which they did not do from the previous grades. Grade 9 learners most of them are not familiar with the topic chemical changes. That is where learners their participation is passive and out of topic showing that they are not coping with the topic. But the topic that is, it deals with every day experiences which form part of the topic. But from my own observations learners are not coming out to the topic, even today I could see that learners are not really aware of those chemical changes at home

TI: So what should be done for learners to be aware of these daily life experiences which can be part of the topic chemical changes.

T1SSI: Well aaa, what is important for us as teachers is to know the environment where learners come from. Then from there on the topic chemical changes we can include examples such as cooking, painting houses, erecting fences since children from these households they are coming from fence homestead both from wood fences and wire fences. Also using fire wood to cook and many others which are found within where they stay can be used once they come to know what a chemical change is all about. Once they know the type I think even the participation can increase in class.

TI: is that all?

T2SSI: Okay Ms. Likando, thank you so much aaammm, with me every time and then when I conduct lessons on the topic chemical changes, in my own capacity chemical changes is an enjoyable topic because it is definitely one of the practical topics that I can definitely do with my learners. It is one of the most interesting topic and it is not much challenging to teach like any other topics as you teach. Why so, it is because aaa within the topic itself, you have lot of examples of practical's that you can do of which learners can aaaa carry out without an investment of money or fund to buy anything. Definitely, it might only depend on natural resources that are available within the area itself. So to me it is one favourite topics for now of my.

2.Could you please tell me how you introduce the topic chemical changes?

T1SSI: Yaaa... mmmm normally I would eeee in actual fact, I will start by doing, doing some actions in class or by doing an activity for example like tearing a paper, moving a desk, opening the window things like that and then learners will normally or try to identify what I am doing and is what is exactly is happening there. Then after that, I will also ask them to come up with their own examples regarding the changes which they know are physical. So I think that is how I introduce the topic. They first have to know the physical change before I move to chemical change.

T2SSI: Well, we have different ways, but aaaa with eee changes usually, in most cases, I would sometimes bring in aaa mmm, a match stick, then with pieces of paper or sometimes I bring a piece of wood which is burnt, and then I bring in some little ash. You ask learners what is their experience from home when they look at the two different objects. If not that is when you can definitely, you can also engage and imply one of the upper introductions like you ask learners to think back maybe let's say the way the environment was in the past compared to now. What differences are there and those differences you ask learners if they are permanent or they are not, are they like still as they were before or how. As they engage in engage in that discuss, definitely you will be able to site some of the chemical changes that are occurring within the area itself. And from that, you can pick the point out and then tell the learners exactly what chemical changes is all about.

3.What do you think are the enablers and shortcomings when teaching the topic chemical changes?

T1SSI: Aaa…mmm… okay since it is a topic with everyday examples, there are a lot of examples which can be used to enable teaching the topic chemical changes. You can bring what is affordable and accessible around and within the environment. There are a lot of practical activities and experiments which can be done towards enabling the topic. Learners also have some of the experiences regarding the topic. Some of these experiences come from home and we can be able to bring out those experiences. But unfortunately our situations in our schools does not allow us to do some of the experiments and investigations as it is time consuming and we have to complete our work for the term on time. As I am speaking, we don't have appropriate instruments and equipment's even to show some videos to the learners. For example, the kettle in which I tried to boil the water just to realise that the plugs are not working. The environment where we are living does not allow us to explore IT methods of teaching and using learners' experiences also waste a lot of time. The school basically is under resourced, so teachers has to make plans to enable the topic to the learners.

T2SSI: aaaa thank you for the question aaa mmm the question is quiet good mmm if you look at the, what are enables me to be effectively deliver content about chemical changes to the learners, aaa mmm its about sorry for that….

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practical, it is one of the most challenging aspect we have but all in all its only that I could say about.

TI: If I may ask, do you normally perform practical activities in the classrooms.

T2SSI: Ammm sometimes we do practical tasks and activities in the lessons and experiments yes but, then there are challenges I normally experience regarding practical activities. It is that of eee sometimes the environment doesn't allow to perform some of the practical activities. For example, let me say for instance maybe you are conducting a combustion reaction which involves burning and then you end up having maybe those learners are asthmatic aaaa and then you have to take them outside and then they might miss some things out. On the other hand, it is time consuming and then you end up like sometimes a 40minute period it won't be enough to carry out the whole experiment at hand. So usually when we have such situations we make it like two periods lesson whereby the first lesson it goes for theoretical learning and then the next one is only used for practical's. So that way at least we are going to be there.

4. What do you do to make learners understand what you teach?

T1SSI: Yaa…aaa. So eee the way I make learners understand is simply to try and use practical work which I sometimes hardly do. Every day experiences which I normally give will explain some of the things for learners to understand. Like a learners gave an example of frying an egg as chemical change, so I have to look at other activities because not all of them are frying eggs at home. So I do other activities whereby the learners they can see in class within the environment which are easily accessible like opening a window, burning a paper, opening a door, the type of little things which I can exercise to check if learners they do understand.

T2SSI: Well, aaaa mmmm, its really quiet challenging sometimes, because in most cases learners are on different levels, some would understand from the theoretical teaching. Some, they would definitely need that part of, of practical's and other staff. So for you to be able to make them understand. You have to use at least to more than one method of teaching. The teaching which at least will involve all learners and to cater for all the learners like for example, if I am to carry out, if I am to conducting a lesson about chemical changes, you would realise that there are some learners who might understand the first part, just when you introduce as you are explaining and all that, but there are some learners who will definitely won't. So I do

much of aaa learner centered and ee learners have to be 100% involved within the lesson. And then that is maybe through questions and answers and sometimes in most cases we do now hands on task whereby the learners they have to do a lot of practical's, they have to experience things, they have to see things happening they have to all in all, I would say they should carry out observations. So at least by that way you are, will be totally convinced that definitely not all my learners they are totally definitely understood. But for me to be able to know that everything is okay my learners understand the topic of the lesson, I usually use aaa sometimes to be questions and answers after the lesson or sometimes I give a class activity or sometimes I give them a homework, I would give them an investigation any of that for as long as it can measure the level of their understanding regarding the topic itself sooo that's all.

5. How do you know that what you have taught, learners have understood?

T1SSI : I normally work more on learner centered way. Where I normally try to ask questions after a certain topic is completed and I give a task. I also use questioning and answering method during teaching and learning. When I ask learners few, few questions and if the answers are not satisfactory I move back and repeat myself and assess them again through these questions and answers. After elaborating again, I give a short class activity and then ask them individually to see if they achieved the competencies for the lesson before I move forward. And then I bring in available and affordable materials like burning a candle, at least fire is burning they can see. Then they can relate what they see in class and what is within the environment, maybe bringing in those everyday experiences might help learners to understand for me to know also if they understand. After completing the topic. I don't wait I test them immediately so that I know how should I move forward. You could see when I was asking learners whether opening a door is physical or chemical

T2SSI: Good question, aaaaammm in that case like I mentioned earlier, sometimes I conduct a dialogue with learners, talking to them if they understood the lesson. I would ask learners sometimes to be in form of groups or sometimes they sit in pairs, they will have a set of questions based on the specific competencies that they would be asking one another and then as they present to the class in my presence and the presence of all learners. Definitely, it will measure how the understanding of the learners but that is not reliable because it is a little bit partial. So what you do you will bring back to the written work where they have to carry out

some tasks. Either it is homework, classwork, or test or sometimes an investigation or even use what comes back to you on those tasks. It will be able to measure the level of understanding eee regarding the topic itself. Soo in that case usually it works out. But not only that sometimes I would send learners outside where they have to carry out observations within the environment and then it might be for a day or two or a week, maximum sometimes just a week. For what purpose, it's for them at least to observe some changes that they can classify as chemical changes which they can bring to class and report as feedback and these eeee in that case you shall then learners learn from each other. If that happens I shall be satisfied that my learners have quietly understand the topic.

Categories	Sub-themes	Themes
T1SSI: Yaa, Its actually an important topic and very useful. It is only that learners in grade 9 regard it as a new topic which they did not do from previous grades. Grade 9 learners most of them are not familiar with the topic of chemical changes. That is where learners their participation is passive and out of the topic showing that they are not coping with the topic. T2SSI: With me every time and then when I conduct lessons on the topic chemical changes, in my own capacity chemical changes is an enjoyable topic because it is definitely one pf the practical topics that I can definitely do with my learners. It is one of the most interesting topics and it is not challenging to teach like any other topics as you teach.		

T1SSI: The topic deals with every day experiences which form part of the topic. What is important for us teachers is to know the environment where learners come from. T2SSI: It is because aaa within the topic itself, you have a lot of practical's that you do of which learners can aaa carry out without an investment of money or fund to buy anything. Definitely, It might depend on the natural resources that are available within the area itself. T1SSI: Yaa..mmm… normally I would in actual fact, I will start doing, doing some actions in class or by doing an activity for example like tearing a paper, moving a desk, opening a window things like that and then learners will normally try to identify what I am busy doing and what is actually happening there. T2SSI: Well we have different ways, but aaa, with eee chemical changes, usually in most cases, I would sometimes bring aaa mmm a match stick, then pieces of paper or sometimes I bring a piece of wood which is burnt and bring in some little ash. You ask learners what is their experience from home when they look at two different objects. If not, that is when you can definitely , you can also engage and imply one of the upper introductions like you ask learners to think back maybe let's say the way the environment was in the past compared to now.		Teacher's perspectives/ attitudes
T1SSI: Aaaa…mmm Okay since the topic with everyday examples, there are a lot of examples which		

can be used to enable teaching the topic chemical changes. You can bring what is affordable and accessible around and within the environment. There are a lot of practical activities and experiments which can be done towards enabling the topic. T2SSI: It is simply based on practical's and use of available resources.		
T1SSI: But unfortunately, our situation in our schools does not allow us to do some of the investigations as it is time consuming and we have to complete our work for the term. The environment where we are living does not allow us to explore IT methods of teaching and using learner's experiences wastes a lot of time. The school basically is under resourced, so teachers have to make plans. T2SSI: You would find some learners who are not practically oriented to carry out experiments and so forth. And especially, there are some learners that you would find in class whereby those learners are anti-social maybe they are not good in socializing, mingling with others. Practical activities is time consuming and then you will end up like sometimes a 4o minute period won't be enough to carry out the whole experiment.		
T1SSI: Yaa.aa... so ee the way I make learners understand is simply to try and use practical work which I sometimes hardly do. Every day experiences which I normally give will explain some of the things for learners to understand. So I do other activities whereby learners they can see in class within the environment		

which are easily accessible like opening a window, burning paper, opening a door, the type of little things which I can exercise and check if learners they do understand. T2SSI: They would need the part of practical's and other staff. You have to use at least do more than one method of teaching. So I do much more of learner centred and then maybe through questions and answers and sometimes in most cases we do hands on task, whereby the learners they have to do a lot of practical's, they have to experience things, they have to see things happening they have to all in all, I would say they should carry out observations. I give class activity or sometimes give homework.		Teacher's experiences and pedagogical insights
T1SSI: I normally work more on learner centered way. I normally try to ask questions after a certain topic is completed and I give a task. I also use question and answer method during teaching and learning. When I ask learners few questions and if the answers are not satisfactory, I would move back and repeat myself and assess them again through questions and answers. T2SSI: I conduct dialogue with learners, talking to them if they understood the lesson. I would ask learners sometimes to be in form of groups or sometimes sit in pairs, they will have a set of questions based on specific competencies that they would be using with one another and then as they present to the class in my presence and the presence of all learners. So what you do will bring		

back to written work where they have to carry out some task.		

Appendix J: Sample of lesson preparation

LESSON PREPARATION FORM

TEACHER: Mr Nambici J.	GRADE: 9.	A	B	C	D	E	DATE:
SUBJECT: Physical Science	DAY						

THEME: Matter TOPIC/SKILL: Chemical change

TEACHING AIDS AND RESOURCES TO BE USED: Candle, paper
- Matter Skills chemistry

SPECIFIC COMPETENCIES / OBJECTIVES: (Refer to Syllabus) Learners should be able to:
Understand the process of chemical changes and compare to physical change.

MONITORING OF HOMEWORK DONE:
Check learners previous homework

INTRODUCTION:
learners define the word change by action.

1. Presentation of subject content and learning tasks:

PRESENTATION OF SPECIFIC COMPETENCIES / OBJECTIVES	TIME	CLASS EXERCISES (should be relevant to the specific competencies/objectives)
- Define change to learners	5	
- Explain the two types of change		-learners identify types of changes from experience and Science or at home.
- Give real life situation of changes in our lifes	30	
- Discuss the properties of physical and chemical changes	5	

Appendix K: Sample of lesson presentation Teacher 1

Lesson 1

The teachers greeted the learners and introduced me and my critical friend as teachers in the field of science. Encouraged learners to participated freely. Our presence should not make them intimidated.

Thereafter, the started by asking learners' work from the previous lesson. He moved around checking if learners did the work or not and asked them if they faced any challenges regarding the homework or not. After that the teacher wrote of the chalkboard 'matter' and asked learners what is matter from the previous grades.

L1; everything around us is matter.

Teacher, after that answer he continued by stating that this matter is in three states which we did previously can you name them.

L2: solid, liquid and gas.

T: from that matter we are going to look at topic physical and chemical changes. The teacher wrote it on the chalkboard and asked learners what do they understand by the word change.

There was silence.

The teacher lifted the bag and moved it to a different place and asked the learners what happed to the bag.

L1: The bag was just moved to a different place nothing happed to the bag.

L2: The bag was just shifted.

T: Then what is change?

L1: Change is when something is changed from one form to another.

Teacher: Okay that's a good try. In life there are two types of changes which occurs. What types of changes have you learnt from the previous grades? Anyone who knows the type of changes?

There was silence.

Teacher: The changes starts with a P and a C. Anyone with the idea/

L1: Physical and chemical changes.

T: Yes, that's right. Physical and chemical; changes are revised topic from grade 8 and now our main focus will be on chemical change. What is chemical change:

Class: silence

L2: These are things which are moving to new things.

Teacher: What are these new things.

L3: aaaa materials and substances.

Teacher: Okay, that right. In science they are certain words which we use. Like changing to new things we refer to it as permanent changes. What is the opposite of permanent?

L4: Temporary

T; There are many changes which took place in life. These changes can either be physical changes or chemical changes. For example, the teacher picked two paper, the other paper squashed it while the other one tiered it. Then the teacher asked what type of changes took place.

Group of learners: physical change, some permanent change.

T: one person at a time. What type of changes took place? He pointed at individual learners and answers which were given were for both physical and chemical changes. So the teacher draws a table form on the chalkboard and refer learners to the textbook to identify the properties of physical and chemical changes. The following was written on the chalkboard.

The teacher was pointing at individual learners to read some properties of physical change and chemical change.

T: Now look at the papers which one is tiered and the other is squashed. Are they still papers?

Learners: Yes

T: Did we make a new product from these papers?

Learners: No

T: What did we do to the papers?

Learners: The papers only change the shape and the size.

T: Now these type of changes which occurred, are they physical changes or chemical change. Please read the properties again before you give me the answer.

L1: Physical change.

T: That's right, can you explain why you say so.

L2: they are still paper, no new substances are formed and the changes which are there are temporary.

T: That's right. Any other examples of physical changes:

L3: building a house.

Teacher: what types of changes are there.

L4: some might be temporary while others might be permanent.

Teacher: Yes, I agree with you. Now can you give me changes which are permanent.

L5: Frying an egg.

T: Yes, it is a chemical change and asked how many learners used to fry eggs at home. Only three learners raised up their hands.

L6: but we used to eat cooked eggs in the dining hall. It is also a chemical change when cooking eggs.

T: yes, that is true. The teacher took a match stick and lit a candle. The teacher gave it to a learner and asked other learners what type of change was it.

Learners: Others stated physical while other chemical.

The teacher again reminded learners to look at the properties of physical change and chemical change. And then asked learners to look at the burning candle and look at the properties involved.

Learners: Heat is involved- it can be physical or chemical

Melting involved- which is forming the wax

Smoke involved- which is a result of burning

Rope burning- which is changing to black / ash

T: Which changes are chemical

L1: Rope burning which formed a smoke is chemical change.

T: Yes, that's right. Another one?

L2: Wax melting is physical change.

T: Yes, that's right. The teacher showed a burned a paper and asked learners what type of change is it.

L3: Chemical change.

Teacher: The teacher showed a burned match stick and asked learners what type of change is it.

L4: Chemical change.

T: why is it that burning a match is a chemical change? Refer to the properties of chemical change.

Learners: changes are permanent, they are not reversible and changes are permanent.

T: That is correct. Now to summarise the properties of physical change, the appearance, size, colour, shape and position might change but they are still the same substances. The teacher was moving around having eyes contact with the learners. The learners did not sit in ground but they were 1m apart from each other. Moving forward, the teacher poured water in an electric kettle and wanted to boil the water but unfortunately the plugs were not working. It showed that, the

teacher did not check the plugs in advance. So he asked learners what will happen to the water in the kettle if the plugs were working.

Learners: The water will boil.

T: is it still the same water

Learners: yes

T: Now boiling water is it a physical or chemical change?

Learners: Physical change

The teacher explained that even though heat is involved, it is still the water. The changes of state such as boiling which forms water vapour is a physical change because nothing new is formed and the properties of water are still there. I would say that all the phase changes of matter are physical changes.

L1: How do we reverse the water which have evaporated.

T: through the process of condensation when a gas is turned to a liquid. If I can give you another example where an ice block is taken from the fridge and then after some time what will happen to that water.

L2: It will start melting.

Teacher: What will happen to the meted water if you put it in the fridge again.

L3: it will be frozen again.

Teacher: How do call that process?

L4: freezing

T: yes, that is it. So the changes of state matter are physical changes. In the afternoon you should come back and copy notes which I will write on the chalk and the homework to be completed.

Appendix L Sample of lesson presentation Teacher 2

Lesson 1

Teacher started greeting the learners and introduced me and my colleague. He let learners to feel free and never to mind that there are people around them.

The teacher started to introduce the lesson.

T: There are different changes in everything we do. What is change learners.

L1: changing the life style, changing behavior and a lot of things.

T: In science what things normally changes.

L2: substances

T: How do they change.

L3: From one form to another.

T: Yes, substances change from one form to another. There are two types of changes which normally occurs in our everyday life. What are these changes if you can recall from your previous grades?

Learners were silent.

The teacher folded the paper and asked learners, if you can recall from the previous grade, when I am folding the paper, what type of change is it.

L1: Physical change.

Teacher burned a paper and asked learners what type of change is it.

L2: Chemical change.

Teacher asked learners what is a physical change and a chemical change

L3: something which we can see with our own eyes and chemical change is something changing without as seeing it changing.

T: That is a try, and any other learner, what can you recall about physical and chemical change.

L1: I can recall that in physical change, the changes are temporary.

T: That is correct and what about a chemical change.

L2: I can recall that the changes are permanent.

The teacher put a table form on the chalkboard to different physical and chemical changes. The used squeezing a paper, pouring hot water from a flask, the changes of state such as melting, boiling, evaporation, condensation, sublimation/disposition which are states of matter as physical change.

The teacher continued with chemical changes and asked examples of chemical changes.

Learners mentioned, frying an egg, burning a paper, burning wood as examples of chemical changes.

The teacher asked learners why those examples are regarded as chemical changes. The teacher referred to the learners to check properties of chemical changes from the textbook.

Learner reading from the textbook, they are permanent changes, they are difficult to reverse and they form new substance.

The teacher showed the burned match stick to the learners and asked them what did they see.

L1: The match stick turned to black.

T: meaning?

L2: a new substance is formed.

The teacher elaborated that in chemical change, they are difficult to reverse and they form permanent substances. The notes were summarised on the chalkboard.

Teacher asked learners what are other examples of chemical changes?

L1: mixing sugar and water is a chemical change.

The teacher asked why is it a chemical change.

The learner said because the sugar disappeared, it has changes to another form.

The teacher poured sugar in water and stirred and asked learners what happened to the sugar.

A learner answered by stating that the sugar disappeared.

The teacher continued by asking whether it is a physical change or chemical change.

Some learners stated as physical change while others as chemical change.

The teacher asked learners where does salt from in our country Namibia. The learners answered that from Walvis Bay and Swakopmund. The teacher continued did you get the piles of salt from those areas? A learners answered, it is from the sea water which is evaporated. The teacher followed up, how sea water taste. A learners answered by stating that it is salt and the water is evaporated. The teacher continued is it not the same as the sugar which we dissolved in water? In fact, we not say the sugar disappeared rather the sugar has dissolved. So check on the examples of physical changes, where does evaporation fall to get the sugar back? Is it a chemical or physical change?

Learners: It is a physical change

T: The solution of sugar can be evaporated and get the sugar back. You can go and try it at home and see what happens.

A learner asked what about when you are mixing oros drink with water, they are all liquids is it a physical change or chemical change?

T: Anyone who has an idea of what she is asking? What do you think.

There was silence

T: As long as you see mixing without heating the mixture, it is a physical change because they are other methods which can be used to separate mixtures, such as chromatography, simple distillation and fractional distillation. So go and read on the chemical and physical properties.

T: I think it is time, I am giving you a task to go and do, when you knock off today, be observant, go and find out what is happening in our environment and surrounding. Go and findout which changes are physical and which changes are chemical. Before we start with our next lesson, you are going to report to class.

Appendix M Reflections and Stimulated Recall Interviews for Teacher 1 and 2

After watching the videos, the follow-up questions were asked as follows:

- **How did you feel when you were watching the videotaped lessons?**
- **How you feel about the whole research process?**
- **What made you to plan those activities and materials used in your lessons as you did?**
- **Do you think the learners have mastered the concepts and content of the topic?**
- **If you were to teach your lessons again what would you do differently?**

Ohh, I feel so good watching these videos while teaching my learners. This is real. If these videos can be programmed and let the learners watch them, it could motivate them to fully participate in the lessons. Learners could see themselves in action and they used to behave in class. They could see themselves in these video for the first time which could be an interesting thing to them. I can see in these videos that I have to direct learners to the answers which I think I have to improve on that. They have to read more on the textbooks which we give them so that they can think. Also I think I did not bring much materials from outside, those examples of physical change and chemical change.

The examples which I performed, it looked as if they forget examples from the previous grades. But these examples are easily understandable by learners. I think in lesson 1, I have put much effort than in lesson 2 and 3.

Why do you think so?

Because I did not give learners to do an activity in between. If you check on lesson 2 to 3, we did self-mark and corrections is when I continued with teaching. I think I need to do more research regarding the resources to be used.

This research actually gave me some positive vibe as a teacher. It really taught me on how one should be prepared. It put me in that aaa trying to give the best to the learners in this regard. In actual fact, it actually helped me to be more prepared and aaa do more research on the content that I am going to teach. So that really helped me to learn something new that when you are going to present something, be prepared thoroughly on that one. It showed me that I need to be

prepared all the time because honestly, there is sometimes a relaxation of planning, bringing in resources and support the teaching and learning.

Hmmmm, I performed those activities regarding the topic chemical changes because, what actually made me to perform them is that they are the simple examples, that is at the level of learners at my school here. It was less costly and as we are in the rural area, we struggle to have those media resources and devices that we do not have access to them. These resources and examples which I used are really basic learners can learn from them. So looking at for example, when I was burning a candle, it gives off light, smoke, there was candle wax, in that regard, it was easy to ask questions thereafter by referring to the changes that they could observe. As you know that when you are teaching, seeing is believing that is why I used those examples.

Aaaa well, there are some new concepts that learners were hearing for the first time. As I could see in the video lessons that, I think I still need to re-teach those concepts. These were words like exothermic, endothermic, reversible, reactant, product and others but then I gave examples from our daily life experiences that we have. So I think It was very easy for some learners to understand and I think that whatever topic one starts, it is better to start familiarising yourself with the concepts/ terms and content of the topic.

If I have another chance, I could do something different yes. I could prepare more, bring different types of resources for learners to understand more. I would think of some practical activities which can make learners understand more and allocate time for the afternoon to do those activities. The examples which I gave such as ice melting, boiling water and others could be done practically and it is not something which is difficult to do. It is only that time is not always on our side.

Reflections and Stimulated Recall Interviews for Teacher 2

- **How did you feel about the whole research process?**
- **How did you feel when you were watching the videotaped lessons?**
- **What made you to plan those activities and materials used in your lessons as you did?**
- **Do you think the learners have mastered the concepts and content of the topic?**
- **If you were to teach your lessons again what would you do differently?**

The whole research process was fine, no problems which I did not encounter problems with the researcher. She would always call me if I will be able to accommodate her in my schedules to come and observe the lessons. He will be always and on let me know that she is already. I would say I was willing to work with her in the research project as this project helped me to improve teaching practice. The way I have taught the lessons made me realise that that I could change it in another way to make it better. The research also taught me that whenever you have to teach a topic, you have to read more on that topic so that you will be able to teacher further on the topic. Whenever you making an appointment to come I would read and read so that I am fully prepared.

The lessons were so good and interesting. The participation from the learners was quiet impressive and I would say learners participated. They were engaged in the lesson as I brought those materials which were known to them. According to my observation, they showed interest at the same time some were active. It was my surprise to me as I was explaining rusting that they know it better from their home as '*omureru*' and it showed that they wanted to know more about the topic. I also learned something new from them as they gave examples of chemical change happening within the environment. So I planned my lessons and see to it that I deliver my lessons the way I planned then. Some learners asked questions to which indicated to me that they were interested of understanding the topic.

I choose those activities and resources which I gave to the learners because those materials and activities enable learners to use raw materials that are just surrounding the environment where they live, there is no need to and buy from the laboratories but can be found within the shops around. The teacher has not to worry about those lack of chemicals in the school laboratory. That means, it allows them to be able to use raw materials that are surrounding whereby they are even able to explore the environment whereby they are able to see the new chemical changes that are taking place within their reach, within their surrounding and environment at large.

If am given the opportunity to teach again, I would have to improve of some parts of the lesson, it will be to change the time frames of the lessons, so that at least we will have theoretical lessons which will be then later followed by practical activities and lessons because some of the activities require more time to observe and also to draw conclusions from them. So on that note it will be wise enough plan our activities and time properly for us to see to it that we can also accommodate more time for those activities.

As I was reading around the topic and after teaching the lessons, I realized noticed that chemical changes take place on a daily basis. So as I was teaching the topic itself, it taught me a lot and learnt a lot. As most of the learners tried to gather and bring some examples together on what type of changes taking place in our everyday life. I noticed that there are a variety of them from what I already know It added some insight, it gave me a highlight as to what is going on within the surrounding and therefore, I got so interested in the topic as it requires most my learners to be able to explore and come up with their own research and understand the knowledge of gathering of information. All that to me was quiet good, therefore I appreciate that I have learnt a lot as well little did I know that more examples will emerge from the learner's observations within the surrounding. I will conclude by saying that I really enjoyed the lessons with the learners.

Thematic Approach: Codes and Sub-themes

Yellow: Views and feelings about lessons taught

Red: Views on how they felt about the whole research process

Green: Supporting materials and presentations

Dark Blue: Missed opportunities in mediating the topic chemical

TI: How do you feel when you were watching the videotaped lessons?

T1: Ohh, I feel so good watching these videos while teaching my learners. This is real. If these videos can be programmed and let the learners watch them, it could motivate them to fully participate in the lessons. Learners could see themselves in action and they used to behave in class. They could see themselves in these video for the first time which could be an interesting thing to them. I can see in these videos that I have to direct learners to the answers which I think I have to improve on that. They have to read more on the textbooks which we give them so that they can think. Also I think I did not bring much materials from outside, those examples of physical change and chemical

change.

The examples which I performed, it looked as if they forget examples from the previous grades. But these examples are easily understandable by learners. I think in lesson 1, I have put much effort than in lesson 2 and 3.

TI: Why do you think so?

Because I did not give learners to do an activity in between. If you check on lesson 2 to 3, we did self-mark (making themselves) and corrections is when I continued with teaching. I think I need to do more research regarding the resources to be used.

T2: Well, well it is so wonderful and interesting. Is this the way I used to present my lessons? These learners were listening and paying attention to me. It seems they missed their teacher a lot, so they want to be taught and learn. Look at how learners were answering to the questions. They were surprised when they saw those materials. They thought we were going to cook. When

I ask questions to the learners, I look direct to the so that they look at me and they would now that I need answers from them. These videos can influence a person to be taking videos when you are teaching and watch them later.

TI: How did you feel about the research process?

T1: This research actually gave me some positive vibe as a teacher. It really taught me on how one should be prepared. It put me in that aaa trying to give the best to the learners in this regard. In actual fact, it actually helped me to be more prepared and aaa do more research on the content that I am going to teach. So that really helped me to learn something new that when you are going to present something, be prepared thoroughly on that one. It showed me that I need to be prepared all the time because honestly, there is sometimes a relaxation of planning, bringing in resources and support the teaching and learning.

T2: The whole research process was fine, I did not encounter problems with the whole research process. You would always call me if I will be able to accommodate you in my schedules to come and observe the lessons. You will be always and on time let me know that the whole program and what we are going to do. I would say I was willing to work with you in the research project as this project helped me to improve teaching practice. The way I have taught the lessons made me realise that I could change it in another way to make it better. The research also taught me that whenever you have to teach a topic, you have to read more on that topic so that you will be able to teach further on the topic. Whenever you making an appointment to come I would read and read so that I am fully prepared.

TI: Were you reading more because of the research?

T2: No, No, it's only that when someone have to observe the lessons you need to be more prepared. I used to prepare my lessons but then sometimes I just give activities.

T2: The lessons were so good and interesting. The participation from the learners was quiet impressive and I would say learners participated. They were engaged in the lesson as I brought those materials which were known to them. According to my observation, they showed interest at the same time some were active. It was a surprise to me as I was explaining rusting that they know it better from their home as '*omureru*' and it showed that they wanted to know more about the topic. I also learned something new from them as they gave examples of chemical change

happening within the environment. So I planned my activity lessons and see to it that I deliver those activities the way I planned then. Some learners asked questions to which indicated to me that they were interested of understanding the topic.

What made you to plan those activities and materials used in your lessons as you did?

T1: Hmmmm, I performed those activities regarding the topic chemical changes because, what actually made me to perform them is that they are the simple examples, that is at the level of learners at my school here. It was less costly and as we are in the rural area, we struggle to have those media resources and devices that we do not have access to them. These resources and examples which I used are really basic learners can learn from them. So looking at for example, when I was burning a candle, it gives off light, smoke, there was candle wax, in that regard, it was easy to ask questions thereafter by referring to the changes that they could observe. As you know that when you are teaching, seeing is believing that is why I used those examples.

T2: I choose those activities and resources which I gave to the learners because those materials and activities enable learners to use raw materials that are just surrounding the environment where they live, there is no need to and buy from the laboratories but can be found within the shops around. The teacher has not to worry about those lack of chemicals in the school laboratory. It allowed me and them to be able to use raw materials that are surrounding whereby they are even able to explore the environment whereby they are able to see the new chemical changes that are taking place within their reach, within their surrounding and environment at large

Do you think the learners have mastered the concepts and content of the topic?

T1: Aaaa well, there are some new concepts that learners were hearing for the first time. As I could see in the video lessons that, I think I still need to re-teach those concepts. These were words like exothermic, endothermic, reversible, reactant, product and others but then I gave examples from our daily life experiences that we have. So I think It was very easy for some learners to understand and I think that whatever topic one starts, it is better to start familiarising yourself with the concepts/ terms and content of the topic.

If you were to teach your lessons again what would you do differently?

If I have another chance, I could do something different yes. I could prepare more, bring different types of resources for learners to understand more. I would think of some practical activities

which can make learners understand more and allocate time for the afternoon to do those activities. The examples which I gave such as ice melting, boiling water and others could be done practically and it is not something which is difficult to do. It is only that time is not always on our side.

T2: If am given the opportunity to teach again, I would have to improve of some parts of the lesson. It will be to change the time frames of the lessons, so that at least we will have theoretical lessons which will be then later followed by practical activities. And lessons because some of the activities require more time to observe and also to draw conclusions from them. So on that note it will be wise enough to plan our activities and time properly for us to see to it that we can also accommodate more time for those activities.

As I was reading around the topic and after teaching the lessons, I realised, noticed that chemical changes take place on a daily basis. So as I was teaching the topic itself, it taught me a lot and learnt a lot. As most of the learners tried to gather and bring some examples together on what type of changes taking place in our everyday life. I noticed that there are a variety of them from what I already know It added some insight, it gave me a highlight as to what is going on within the surrounding and therefore, I got so interested in the topic as it requires most my learners to be able to explore and come up with their own research and understand the knowledge of gathering of information. All that to me was quiet good, therefore I appreciate that I have learnt a lot as well. Little did I know that more examples will come out from the learner's observations within the surrounding. I will conclude by saying that I really enjoyed the lessons with the learners.

TI: Thank you so much for having thus time with me to do some reflections and follow up questions on the lessons taught.

Categories	**Themes**
T1: Oh, I feel so good watching these videos while teaching my learners. This is real. It these videos can be programmed and let the learners watch them, it could motivate to fully participate in the lessons. Learners could see themselves in action and how they used to	

behave in class. They could see themselves in these videos for the first time which could be interesting to them. **T2**: Well, well it is so wonderful and interesting. These learners were listening and paying attention to me. Look at how learners were answering question. They were surprised when they saw those materials. **T2**: These videos can influence a person to be taking videos when you are teaching. **T1**: I can see in these videos that I have to direct learners to the answers which I think I have to improve on that. Also I think I did not bring much materials from outside, those examples of physical and chemical change. The examples which I performed, it looked as if they forget the examples from the previous grades. But these examples are easily understandable by the learners. **T2**: The lessons were so good and interesting. The participation from the learners was quiet impressive and I would say learners participated. According to my observation, they showed interested at the same time they some were active. It was a surprise to me that as I was explaining rusting, that they know it better from their home as 'omureru'and it showed me that they wanted to know more about the topic.	Views and feelings on lessons taught and the whole research
T1: This research actually gave me a positive vibe as a teacher. It really taught me on how one should be prepared. It actually helped me to be more prepared and aaa do more research on the content that I am going to teach. It helped me to learn something new that when you are going to present something, be prepared thoroughly on that one. . It showed me that I need to be prepared all the time because honestly, there is sometimes a relaxation of planning, bringing in resources and support the teaching and learning. **T2:** The whole research process was fine, I did not encounter problems with the whole research process. You will be always on time, you let	

me know that the whole program and what we are going to do. I would say I was willing to work with you in the research project. The project helped me to improve teaching practice. The research taught me that whenever you teach a topic, you have to read more on the topic so that you will be able to teach the topic further. Whenever you making an appointment to come, I would read and read so that I am fully prepared.	
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something different yes. I could prepare more, bring different types of resources for learners to understand more. I would think of some practical activities which can make learners understand more and allocate time for the afternoon to do those activities. T2: If I am given another opportunity to teach again, I would have to improve of some parts of the lesson. It will be to change the time frames of the lessons, so that at least we will have theoretical lessons which will be followed by practical activities. And lessons because some of the activities require more time to observe and also to draw conclusions from them.T2: As I was reading around the topic and after teaching the lessons, I realised, noticed that chemical changes take place on the daily bases. As most learners tried to gather and bring some examples together on what type of changes taking place in our everyday life. I noticed that there are a variety of them from what I already know, it added some insight, it gave me a highlight as to what is going on within the surrounding. Therefore, I got interest in the topic as it requires most of the learners to be able to explore and come-up with their own research and understand the knowledge of gathering information. So I will conclude by saying that I really enjoyed the lessons with the learners	