Exploring how Grade 11 Physical Science learners make sense of the concept of rates of reactions through the inclusion of the indigenous practice of making *oshikundu*: A Namibian case study

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By

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Declaration

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and has not been previously submitted at any other university for degree purposes. Where I have drawn on the words or ideas of others, these have been acknowledged using complete references according to Departmental Guidelines.

Signature: Date: 04 April 2017

Dedication

This thesis is dedicated to my former Grade 3 teacher, Mrs Pregelina Vimbulukeni Shiweva. It was because of her efforts that I am who I am today. She ranked me at position one for the first time, in her class. This encouraged me to work harder and enabled me to reach this academic level.

Abstract

It has been observed that the teaching and learning of the concept of rates of reactions is seen as being difficult for most Namibian learners. Concerns have been expressed in Examiners' Reports about candidates showing little knowledge of the topic 'rates of reactions'. Hence, this study sought to explore how indigenous knowledge and practices through a practical activity of making *oshikundu,* enabled or constrained learner-engagement and sense-making of the concept of rates of reactions in Namibian schools.

Underpinned by an interpretive paradigm, the study tried to describe and understand how learners make sense of their world. Within the interpretive paradigm, a mixed-method case study approach was adopted. It is informed by Vygotsky's socio-cultural theory, which recognises that learning and meaning-making are represented as originating from social interactions among individuals. The research study was conducted in a rural secondary school in the northern part of Namibia with Grade 11 Physical Science learners. Purposive sampling techniques were used to select three learners from the class, as the interview sample. A pre-test was used to gather data on the type of prior knowledge that Grade 11 Physical Science learners had of concepts related to rates of reactions. The pre-test's content was validated by two Physical Science specialists. Observations were used to explore how learners make sense of rates of reactions during lessons. In addition to observations, interviews and a post-test were used in order to gather data on how the practical activity of making *oshikundu* enabled or constrained Grade 11 Physical Science: (a) learner engagement and (b) sense-making of the concept of rates of reactions.

The findings of the study found that learners were more engaged and participated more fully in class than in previous year when the indigenous practice of making *oshikundu* was incorporated during the science lessons. The study thus recommends that indigenous knowledge and practices be integrated into Physical Science classrooms for effective teaching and learning and sense making of science concepts.

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List of abbreviations and/or acronyms

AASIKS	African Association for the Study of Indigenous Knowledge Systems
AIDS	Acquired Immuno Deficiency Syndrome
ARSI	Alaska Rural Systemic Initiative project
BEd-Hons	Bachelor of Education Degree with Honours
CBL	Case-Based Learning
HIV	Human Immuno-deficiency Virus
ICT	Information Communication Technology
IK	Indigenous Knowledge
IKS	Indigenous Knowledge Systems
ILSA	International Large-Scale Assessment
IRF	Initiation-Response-Feedback
LCE	Learner-Centered Education
LoLT	Language of Learning and Teaching
MBEC	Ministry of Basic Education and Culture
MEC	Ministry of Education and Culture
MEd	Masters in Education Degree
MoE	Ministry of Education
NCBE	National Curriculum for Basic Education
NIED	National Institute for Educational Development
NSSCO	Namibia Senior Secondary Certificate Ordinal level
PEEOE	Predict-Explain-Explore-Observe-Explain
PISA	Programme for International Student Assessment
PoPCI	Popular Participation in Curriculum and Instruction
TEK	Traditional Ecological Knowledge
TIMSS	Trends in International Mathematics and Science Study
TK	Traditional Knowledge

CHAPTER ONE

SITUATING THE STUDY

1.1 Introduction

The main goal of the study was to explore how Grade 11 Physical Science learners make sense of the concept of rates of reactions through the inclusion of the indigenous practice of making *oshikundu*. In this chapter, the background of the study focuses on the international and regional context and the Namibian Science curriculum is then described. The statement of the problem and potential value of the study are presented. A summary of the research goal and questions and the theoretical framework that underpins the study are highlighted. The data gathering techniques and definition of key concepts are provided. The thesis outline is discussed and the chapter ends with some concluding remarks.

2.1 Background to the study

One of the preliminary steps to completing research is the background to the study. The background to a study with regards to research, includes a review of the area being researched, current information surrounding the issue, previous studies on the issue, and relevant history on the issue (Alleyne, 2016). Ideally, the study should effectively set forth the history and background information of the research problem. The purpose of the background information for any study is to help the researcher to prove the relevance of the research question(s) and to further develop the research (*ibid.*).

2.1.1 The international and regional context

In order to understand science and mathematics education worldwide, the Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS) were developed to investigate educational phenomena in different countries (Liou & Hung, 2014). According to the international large-scale assessment (ILSA), these bodies (PISA & TIMSS) provide periodic information on comparisons of learners' science and mathematics education across countries. Both PISA and TIMSS programmes are part of the ILSA but have different aims and testing procedures. The purpose of PISA is to survey scientific, mathematical, and reading literacy levels amongst 15-year-old learners, in order to measure how well they can apply knowledge and skills to solve problems in everyday life situations. For TIMSS, the aim is to survey learners' achievements in science and mathematics by measuring 4^{th} to 8^{th} graders' mathematics and science knowledge and skills, broadly aligned with the curricula of participating countries (Liou & Hung, 2014).

As anticipated by Liou and Hung (2014), the collected data from PISA and TIMSS in both national and international contexts can be used by researchers to investigate related factors associated with learners' performance or with educational related achievements, such as learners' interest in science across the world and understanding learners' application of this knowledge to real life contexts.

In South Africa for, example, the TIMSS of 1995 and 1999 national assessment studies, revealed that learners' performance was very poor in comparison with other learners from other countries (Howie, 2004). According to the study, English usage in the classroom, learners' socio-economic status and learners' perception of the importance of mathematics and science, amongst others, were factors that caused the poor performances of South African learners.

The research study carried out in Nigeria by Olakanmi (2015) on the effects of a web-based computer simulation on students' conceptual understanding of rates of reactions and attitude towards chemistry, shows that the concept of 'rate of chemical reaction' is one of the most difficult concepts in Physical Science for learners to understand because it is abstract in nature. The study asserts that some teachers also find it difficult to teach the concept, due to misconceptions concerning the concept of rate of chemical reaction. According to the study, poor teaching methods, lack of appropriate educational materials, and a poor attitude towards chemistry, are factors that do not provide opportunities for learners to relate chemistry concepts to everyday life, for meaningful learning to occur (*ibid.*).

Based on research conducted in Thailand, Supasorn and Promarak (2015) posit that "chemical reaction, or chemical kinetics, has been found to be one of the most difficult chemistry topics to understand because it involves mathematical calculations and because there are many factors that influence the rate of the reaction" (p. 121). Research studies find that the problem associated with the teaching of rates of chemical reactions is caused by learners' alternative conceptions (Calik, Kolomuc, & Karagolge, 2010; Kolomuc & Calik, 2012; Supasorn & Promarak, 2015; Yalcinkaya, Tastan-Kirik, Boz, & Yildiran, 2012).

2.1.2 The Namibian context

In order to fulfill its main aims and goals, the curriculum has identified Science and Natural Science as one of the key learning areas to transform Namibia into a knowledge-based economy and one that pursues environmentally friendly and sustainable practices (Namibia. National Curriculum for Basic Education [NCBE], 2010). The Namibian NCBE (2010) states that it is not only important for learners to have knowledge and skills, but also that their identity, culture and values as individuals be of equal importance. The curriculum also points out that, "the concept of knowledge thus embraces indigenous knowledge and local and national culture as well as international and global culture" (*ibid.*, p. 7).

The Namibian Science curriculum places emphasis on practical work in the science classrooms. This is in contrast to the old ways of science teaching in Namibia, where learners had to imagine the phenomena. However, the curriculum does not only suggest the minimum practical work that should be covered in almost every topic, but has gone beyond to provide room for learners to carry out their own practical investigations as part of their everyday learning processes and for assessment purposes. It states that learners have to plan, formulate scientific questions, identify all possible variables, predict the outcomes, carry out the experiments, present the results and make some inferences (draw conclusions) (Namibia. Namibia Senior Secondary Certificate Ordinal level [NSSCO], 2010).

The Namibian Examiners' Reports, however, consistently point to the fact that learners are in practice, not doing enough practical work in their science lessons. Yet in the teaching of Chemistry, there is much scope to motivate learners to engage with the topic, by using more examples from their everyday life, in their community and indigenous processes and knowledge, and by also explaining to them the widespread use of chemistry in commerce and industry; for example, "the economic considerations in the chemical industry such as the availability and cost of raw materials and energy and the importance of chemicals in industry and in everyday life" (Namibia. NSSCO, 2010, p. 23).

Rates of change in chemical reactions can easily be linked to mainstream engineering processes in the economy. Chemical processing is widespread and is found in most industries, and chemical engineers often need to know the ways to control the rates at which chemical reactions take place. Similarly, as discussed more fully below, there are many every day and indigenous (chemical) processes that are the same as those typically used in the science classroom, but with the added value of coming from the local community. The use of more of these local examples will bring greater understanding of some everyday slow and fast reactions, such as the ripening of fruits and rotting of food.

1.3 Statement of the problem

It has been observed that the teaching and learning of rates of reactions is seen as difficult for most Namibian learners. Concerns have been expressed in Examiners' Reports (MoE, 2010; MoE, 2011; MoE, 2012; MoE, 2013; MoE, 2014) about candidates showing little knowledge of the topic 'rates of reactions' and concepts involved, such as how to determine the speed of reaction from the graph, collision theory, activation energy, how to determine and describe factors that affect the rate of a reaction and the effect of the catalyst on the reaction rate. Hence, this study may be used to enhance the learning of rates of reactions in Namibian schools.

Moreover, having taught Physical Science for six years at the secondary phase, I learned that although learners at Grade 12 level are familiar with some of the rate of reaction concepts, they are unable to describe the effects of concentration, particle size (surface area), catalysts (including inorganic or organic) and temperature and light on the speed (rate) of the reaction. In addition, they are unable to describe experiments for investigating the effects of given variables on the rate of reaction, as well as interpreting data obtained from experiments concerned with rates of reactions.

This poor result is connected with the notion that Physical Science, particularly Chemistry, is an abstract subject that has no relevance to common everyday life. The science of chemistry though practiced unknowingly in the everyday life of people, is excluded from school science. The learners' everyday life experiences are not incorporated into school, nor connected with science concepts. As a result, science is not easy to understand and hence, seen as abstract. The neglect of indigenous knowledge and practices of the community in science for academic strategies of teaching and learning, make science abstract to learners nowadays. Hence, some efforts are being made towards indigenisation of science through the use of local materials (Mukwambo, Ngcoza & Chikunda, 2014) and use of mother tongue instruction in science (Kocakulah, Ustunluoglu & Kocakulah, 2005). Despite these facts, many science learners still believe that chemistry is abstract and this is reflected in their below average school marks.

Therefore, drawing on my experience and the findings from Examiners' Reports, I found it appropriate to conduct a more in-depth research into exploring how Grade 11 Physical Science learners might perhaps make better sense of the concept of rates of reactions, through the inclusion of more familiar local processes and/or indigenous fermentation processes, rather than the off-the-shelf industrial chemicals that are usually used to illustrate rates of reactions in the science classroom.

1.4 Potential value of the study

The potential value of this study pertains to the use of the indigenous practice of making *oshikundu*, therefore enhancing conceptual development of scientific concepts, namely, fermentation and rates of reactions. This may help learners to discover that scientific knowledge is part of their everyday lives and through involving the community in teaching science; they will recognise the educational value of their cultural practices. The study is not only aimed at mobilising the use of *oshikundu*, but also to raise awareness in both science learners and teachers, to continually think and make use of traditional knowledge and local practices related to many other science concepts. In addition, the worksheet that I developed for making *oshikundu*, can be utilised by teachers as an example to develop the usage of easily accessible learning and teaching resources (Asheela, Ngcoza, & Enghono, 2015).

Furthermore, the study may be used as a reference point to help teachers explore how traditional knowledge or indigenous knowledge and the practice of making *oshikundu*, may be used to enhance the learning of rates of reactions in Namibian schools. In particular, this study hopes to provide meaningful insights into developing an understanding of how the teaching and learning context through indigenous practical activities, cater for the natural curiosity and eagerness of young people to learn and to investigate and make sense of a widening world.

The inclusion of indigenous knowledge practices into science teaching and learning, is very important for this study. This was because it decreases the abstract nature of science concepts and improves learners' understanding and performance. The concepts are simplified after indigenous knowledge and practices are included and utilised. The study further intends to recognise indigenous knowledge and its contribution to sustainability development; it eliminates the gap between school science and every day science; promotes parental participation and involvement in learning science and, as a Physical Science teacher, the study improved my own teaching practice.

1.5 Research goal and questions

1.5.1 Research goal

The main goal of this study was to explore how Grade 11 Physical Science learners make sense of the concept of rates of reactions through the inclusion of the indigenous practice of making *oshikundu*.

1.5.2 Main research question

How do Grade 11 Physical Science learners make sense of the concept of rates of reactions through the inclusion of the indigenous practice of making *oshikundu*?

1.5.3 Sub-questions

1. What prior knowledge do Grade 11 Physical Science learners have of the concepts related to rates of reactions?
2. How do Grade 11 Physical Science learners make sense of rates of reactions during lessons?
3. How does a practical activity of making *oshikundu* enable or constrain:
   (a) learner engagement?
   (b) making sense of the concept of rates of reactions?

1.6 Theoretical framework

A theoretical framework is an important component of a research study. It grounds the study and guides the methodological design. It also forms a reference point for the interpretation of the research findings (Mpofu, Otulaja, & Mushayikwa, 2013). Similarly to Mpofu et al. (2013), Imenda (2014) posits that a theoretical framework refers to the theory that researchers select to guide themselves in conducting a research project. The theoretical framework for this study draws from Vygotsky's (1978) socio-cultural theory and its value for this study is further unpacked in the literature review.

1.7 Data gathering techniques

Varieties of data gathering techniques were employed to collect data in this study. These methods were:

- Testing (pre-test & post-test);
- Observation; and
- Interviews.

1.8 Definition of key concepts

Some key concepts are frequently referred to in this thesis. These are rates of reactions, sense-making, practical activities, prior knowledge, indigenous knowledge, socio-cultural theory, social interactions, learner engagement and language usage. These are hence defined as follows:

- **Rates of reactions:** a measure of the number of collisions taking place in a single unit of time;
- **Sense-making:** involves turning circumstances into a situation that is comprehended explicitly in words and that serves as a springboard into action;
- **Practical activities:** any science teaching and learning activity in which the learners, working individually or in small groups, handle or observe the objects or materials they are studying;
- **Prior knowledge:** Scientific or non-scientific formal and informal information which learners bring with them into school;
- **Indigenous knowledge:** inherited information and practices which are unique to a particular culture, established and handed over from one generation to another;
- **Socio-cultural theory:** a theory which advances that knowledge is acquired through social interactions in a social context;
- **Social interactions**: the process by which we act and react to those around us;
- **Learner engagement:** willingness to participate in routine school activities, such as attending class, submitting required work, and following teachers' directions in class;
- **Language usage:** a mediation tool, which is the key to the development of scientific ideas and communication in science, in a socio-cultural paradigm.

1.9 Thesis outline

The research study was conducted in a rural secondary school in the northern part of Namibia and the thesis consists of six chapters. The following is an outline of each chapter.

Chapter One, the first chapter of this study explained the goal and structure of the research study. A discussion of the background of the research and the rationale are presented. The statement of the problem, potential value for carrying out the study, research goal and questions, theoretical framework, definition of key concepts and thesis outline are discussed in this chapter.

Chapter Two reviews literature related to the research study. Concepts such as sense-making in science, the role of practical activities, prior knowledge, indigenous knowledge and language in science are discussed. The theoretical framework underpinning the research study, socio-cultural theory, is also discussed in this chapter.

Chapter Three looks at the research paradigm employed and clarifies why a mixed-method approach was used in this study. Testing, observation and interviews are discussed in detail. The use of convenience and purposive sampling techniques are also discussed. Lastly, data analysis, issues of ethics and validity are discussed.

Chapter Four presents, analyses and discusses quantitative data from the pre- and post-test. The results are discussed with reference to the theoretical framework and literature.

Chapter Five presents analyses and discusses qualitative data from observation of lessons and the practical activity and interviews with learners. The results are discussed with reference to the theoretical framework and literature.

Chapter Six outlines the summary of findings and recommendations for further research for this study. The chapter further presents the limitations of this study, as well as some reflections and the conclusion of the study.

1.10 Concluding remarks

The chapter described the background of the international, regional and Namibian Science curriculum context of the study. The research goal and questions were presented. The theoretical framework and potential value of the study were highlighted and definition of key concepts provided. In order to enable the reader to have a clear understanding of the research, the thesis outline was discussed.

The next chapter discusses the literature the study was based on and the theoretical framework of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The main goal of this study was to explore how Grade 11 Physical Science learners make sense of the concept of rates of reactions, through the inclusion of the indigenous practice of making *oshikundu*.

In this chapter, the literature relevant to how learners make sense of the concept of rates of reactions is discussed. This includes the curriculum expectations and conceptual framework. A review of related studies, namely, rates of reactions, sense-making or meaning-making, practical activities, prior knowledge, indigenous knowledge and language and science, are discussed under the conceptual framework. The theoretical framework employed in this study is socio-cultural and is explored to gain insight into how learners make sense of the concept of rates of reactions.

2.2 Curriculum expectations

Before independence, only a few Namibians had access to, and benefited from, education due to apartheid and colonialism (Namibia. Ministry of Education and Culture [MEC], 1993). After independence, the government of the Republic of Namibia developed its National Curriculum for Basic Education [NCBE] (2010), based on the Constitution and Education Act. In order to fulfil its main aims and goals, the curriculum identifies 'Natural Sciences' as one of the key learning areas that empowers learners to think and take responsibility not only for their own, but also for each other's learning and development (*ibid.*). Towards its obligation, the curriculum strives to transform Namibia into a knowledge-based economy characterised by effective and wise utilisation of existing knowledge and the creation of new knowledge. The curriculum further clarifies that it is important to include indigenous knowledge in the teaching and learning practices (Namibia. NCBE, 2010).

The Physical Science syllabus for Namibia Senior Secondary Certificate Ordinal level (NSSCO) is localised and recognises the uniqueness of the learner and its design is consistent with the philosophy of learner-centered education (LCE). LCE implies the active involvement of the learners in the teaching and learning process. Learner-centered teaching provides learners with activities and experiences, which will stimulate them to learn to think and solve problems themselves (Namibia. Ministry of Basic Education and Culture [MBEC], 1998).

The starting point at each stage of a learning process is the learner's existing knowledge, skills, interests and understandings, derived from previous experiences in and out of school (Namibia. MBEC, 1998). However, frequently Physical Science teachers do not recognise this fact by including activities that encourage learners to bring their individual experiences into the classroom and hence acquire and apply new knowledge, using their previously learned knowledge and experiences as the foundation.

The Ministry of Basic Education Sport and Culture [MBESC] (2003) stipulates that, learner-centred education (LCE) presupposes that teachers have a holistic view of the learners, and value the learners' experiences as the focal point of learning and teaching. Teachers should therefore select learning content and methods on the basis of the learners' needs, within their immediate local environment and community. To this end, the curriculum invites educators to consider learners' prior knowledge, which in this context is regarded as indigenous knowledge (IK), through the use of local and natural resources, as an alternative to available modern learning and teaching materials.

The aim of the Namibian curriculum in relation to developing an environmentally sustainable society, is to provide the scientific knowledge, skills, attitudes and values needed to ensure that the environment is respected and sustained, and to develop the ability to make environmentally wise choices in terms of family development, as well as in economic activities (NCBE, 2010).

2.3 Conceptual framework

A conceptual framework was used as an analytical tool to assist in answering the research questions. Key concepts were identified to provide context for interpreting the study findings. The concepts gave direction to this study and are located in different sections that may assist the reader to understand and interpret the structure upon which this study is built on.

2.3.1 Rates of reactions

The teaching and learning of rates of reactions, incurs difficulties for most Namibian learners (Namibia. Ministry of Education [MoE], 2010-2014). For the past five years, concerns have been expressed about candidates showing little knowledge of how to determine the speed of reactions. Examiners' Reports state that changing the rates of reactions was poorly expressed; rate was also confused with terms such as diluted and concentrated.

Similarly, the research carried out in Thailand by Supasorn and Promarak (2015) on implementation of 5E inquiry, incorporated with analogy learning approach, to enhance conceptual understanding of chemical reaction rates for Grade 11 students, found that rates of reactions is one of the most difficult chemistry topics to understand. This is because it involves many calculations and is also due to the many factors that can affect the rate of a reaction. The study revealed that some learners have an alternative understanding of scientific concepts which can be partially correct, but incomplete or just simply incorrect (*ibid.*).

Several studies have been carried out on learners' conception of the topic of chemical reaction rates or chemical kinetics (Supasorn & Promarak, 2015). For example, Yalcinkaya et al. (2012) conclude that the rate of a chemical reaction is a difficult concept for both secondary school learners and undergraduate students. Hence, they advocate that case-based learning (CBL) can be an effective teaching pedagogy for challenging learners' alternative conceptions in the context of rates of reactions. According to the study, CBL is the method of teaching learners the concept, based on the cases of their everyday life. Yalcinkaya et al. (2012) indicate that, "since the cases were generally based on the analogies associated with real-life events, this would help to link students' prior knowledge with the new information" (p. 166).

The research findings of the study by Chairam, Somsook and Coll (2009) to enhance Thai students' learning of chemical kinetics, suggest that "engaging students in inquiry-based practical chemistry classes produces sound learning outcomes in terms of conceptual understanding of chemical kinetics" (p. 111). With the use of experimentation, learners were able to explain the changes in the rates of reactions and had a better conceptual understanding of rates of reactions. In another related study, Olakanmi (2015) postulates that the poor performance of Nigerian learners was because "school classrooms do not provide learning opportunities that require hands-on-activities that are engaging with collaborative or interactive learning settings that would help relate chemistry concepts to everyday life" (p. 628).

The results of an investigation of the effect of conceptual change pedagogy on students' conceptions of rates of reactions by Calik and colleagues (2010), suggest that the teaching intervention assists the learners to overcome their alternative conceptions and to keep their newly structured knowledge in their long-term memories.

In a study by Kolomuc and Calik (2012) to compare chemistry teachers' and Grade 11 learners' alternative conceptions of rates of reactions, the study found that both teachers and learners had the same alternative conceptions. The study maintains that this could be due to the fact that Chemistry teachers may have transmitted their alternative conceptions to the learners. According to the study, some of the alternative conceptions identified were: a lack of understanding of the effect of enthalpy on the rates of reactions; the mechanism of reactions and misunderstanding or misapplication of the relationship between temperature or concentration and the rates of reactions (*ibid.*).

Moreover, having taught Physical Science for six years at the secondary phase, I learned that although students at Grade 12 level are familiar with some of the rates of reactions processes, they are unable to describe the effects of concentration, particle size (surface area), catalysts (including inorganic or organic), temperature and light on the speed (rate) of a reaction. In addition, they are unable to describe experiments to investigate the effects of given variables on the rates of reactions, as well as interpreting data obtained from experiments concerned with rates of reactions.

Therefore, drawing on my experience and the findings from Examiners' Reports, I found it appropriate to conduct research into exploring how Grade 11 Physical Science learners might perhaps make better sense of the different processes involved in learning the concept of rates of reactions, through the inclusion of more familiar local processes and/or indigenous fermentation processes, rather than the off the shelf industrial chemicals that are usually used to illustrate the science of rates of reactions.

2.3.2 Sense-making

According to a study by Weick, Sutcliffe and Obstfeld (2005), sense-making includes turning circumstances into a situation that is understood explicitly in words and that serves as a springboard into action. These scholars understand that sense-making is when meaning materialises, which is a crucial part of language, talk and communication. The authors maintain that, "sense making is about the interplay of action and interpretation rather than the influence of evaluation" (Weick et al., 2005, p. 409). The study analysis suggests that sense-making is retrospective in nature and occurs during socialisation.

In another related study by Ash (2004) on reflective scientific sense-making dialogue in two languages, it was shown that meaning is created dialogically. The study emphasises the importance of physical interaction with scientific phenomena. It advocates the view that physical activities (doing) and dialogic processes (talking) are both necessary to lead to increased learner understanding. The research further maintains that it is significant to consider the ideas and ways of talking and knowing that children from diverse communities bring to science classrooms, between every day and scientific ways of knowing and talking (Ash, 2004). In an attempt to rethink diversity in learning science, Warren, Ballenger, Ogonowski, Rosebery and Hudicourt (2001) echo similar sentiments: that children's ways of knowing and talking constitute scientific practice. Warren et al. (2001) highlight that children especially make sense of science concepts in their own language.

In most occasions, learners cross the boundaries between home and school, between first and second languages, between every day and scientific discourse, and between formal classroom and informal settings. Crossing between these different contexts is called "border crossing" (Aikenhead & Jegede, 1999). Following this notion, it is believed that non-school settings can be the foundation of scientific ways of thinking (Ash, 2004). Ash's (2004) research expands peoples' view of collaborative scientific sense-making, by studying social groups with diverse cultural backgrounds. In the study, a visit to the Splash Zone exhibit at the Monterey Bay Aquarium by a Spanish-speaking family, helped them to cross boundaries between every day and scientific talk, between Spanish and English languages.

2.3.3 The role of practical activities

According to Woodley (2009), practical work in science is defined as "a 'hands-on' learning experience which prompts thinking about the world in which we live" (p. 49). Maselwa and Ngcoza (2003) also echo the same sentiments that the use of 'hands-on', 'minds-on' and 'words-on' practical activities, help learners' conceptual understanding of science concepts. In their study, they developed a Predict-Explain-Explore-Observe-Explain (PEEOE) approach where learners give "explanations for their predictions as well as their explanations, prior to their observations" (p. 650). Similarly, a critical research study in school science by Hodson (1990), also reveals that all the major science curriculum developments advocate hands-on practical work, because it is an enjoyable and effective means of teaching and learning. Likewise, Millar (2010) posits that the understanding of science by learners is mainly developed when learners have opportunities to engage with practical work.

According to Millar (2010), practical work is "any science teaching and learning activity in which the students, working individually or in small groups, handle or observe the objects or materials they are studying" (p. 1). Millar (2010) believes that for a practical activity to be effective, learners must do things they were meant to do with objects and materials, and then be able to recall what they did with these objects and materials. Furthermore, they should be able to think about what they are doing and what they see, using the ideas they were meant to, as well as showing understanding of the ideas the activity is meant to help them learn (*ibid.*).

Though there are various methods employed in the teaching and learning processes, the research study by Gott and Duggan (1996) concludes that "practical work has a key role in the teaching of evidence provided that the type of practical work is selected carefully with a clear purpose in mind" (p. 791). To that end, teachers should plan for practical works that suit the intended purpose. Woodley (2009) believes that practical work is what science is all about. This study points out that presentation and group discussion activities support practical work and are important in developing understanding of science concepts. However, the study also stresses that practical work can be a waste of useful academic time, if it does not meet its objectives or purpose. The research suggests that even though most of the teaching time available is spent on practical work, it is very important for science educators to understand what practical work is and its intended purpose. In the same vein, Maselwa and Ngcoza (2003) found that learners participate actively when doing practical work themselves. However, practical activities need more time and if not properly planned, can waste most of the appointed curriculum time.

According to Hodson (1990), many learners enjoy and are motivated by practical work. Contrary to that, there are also some who do not. This study points out that there are learners who 'get off' if the number of practicals are increased. However, interest, curiosity, excitement and enjoyment can be stimulated if learners are allowed to pursue their own practical investigations in their own way. The study by Hodson (1990) argues that, "practical work, as conducted in many schools, is ill-conceived, confused and unproductive. For many children, what goes on in the laboratory contributes little to their learning of science or to their learning about science" (p. 33). Often, there is a need for science teachers to equate practical activity with various strategies and Woodley (2009) contends that activities such as science related visits, surveys, models, presentations, role-play, and simulation, including the use of Information Communication Technology (ICT), could complement practical work. Even so, this study maintains that these should not be utilised as a substitute for practical work.

The beginning of each stage of a learning process is the learner's existing knowledge, skills, interests and understanding, derived from previous experience in and out of school (Maselwa & Ngcoza, 2003). Although it is not clear how to incorporate prior knowledge during practical work, Maselwa and Ngcoza (2003) argue that respecting learners' experiences is an important aspect for effective learning.

Woodley (2009) and Millar (2010) further advocate that teachers should involve learners more in designing and carrying out experiments (hands-on) and observation (brains-on). Woodley (2009) and Gott and Duggan (1996) stress that, when selected carefully, good practical work helps learners understand science and become good scientists. The current Namibian Science curriculum (2010) is designed to empower learners to think and take responsibility, not only for their own, but also for each other's learning and development. Therefore, teachers are encouraged to design practical activities that encourage individual and group work, thereby involving learners as partners in knowledge creation, rather than only receivers of knowledge.

The role of practical activities is central to good science teaching and learning. 'Hands-on', 'minds-on' and 'words-on' activities are essential when teaching science (Maselwa & Ngcoza, 2003). According to this study, these teaching strategies are very effective. In addition, they help learners forget they are preparing for examinations and enjoy science for what it is – an inquiry process based on exploration. Promoting experiments at home and exploring their surroundings away from the classroom, is also a good strategy to get learners excited about science.

2.3.4 Prior knowledge

To help learners make the most of a new experience, teachers need to understand how prior knowledge affects learning (Roschelle, 1995). This study further postulates that learning starts firstly from prior knowledge, and only later from the presented materials. Kasanda, Lubben, Gaoseb, Kandjeo-Marenga, Kapenda and Campbell (2005) argue that learners learn more effectively when they already know something about a content area and when concepts in that area mean something to them, and are relevant to their particular background or culture. That is, when teachers link new information to the student's prior knowledge, they activate the student's interest and infuse science concepts that incorporate issues from society (*ibid.*).

The research study conducted by Stears, Malcolm and Kowlas (2003) in South Africa highlights the connection between prior knowledge and school science, promoting more engagement and participation for learners with each other and the content. This approach can make the lessons more interesting if the teacher uses what learners know or experience from home. It will also result in higher participation and understanding due to contextualisation of classroom science concepts, through the incorporation of indigenous knowledge (Stears et al., 2003). Likewise, Oloruntegbe and Ikpe (2011) and Rennie (2011) state that effective education of learners is predicated on how learners are able to relate what they learn at school to their daily lives, and how teachers have been helping learners establish such connections during science teaching and learning, which Aikenhead and Jegede (1999) call "border-crossing".

Strangman and Hall (2004) find that learners can easily be turned off if they are taught something that is new and different from their background knowledge. To that end, the research study carried out by Svinicki (2006) on the role of prior knowledge in learning, also reveals that what learners do not know, may turn them off. This study maintains that prior knowledge is necessary to help learners understand and appreciate a new experience or content. However, the effects can have both benefits and shortcomings. The effects are beneficial if the prior knowledge is correct (positive), but can be negative if it contains misconceptions. Teachers thus need to be careful in considering learners' prior knowledge when planning for instruction and in their teaching processes, to ensure that effective teaching and learning takes place.

As Kuhlane (2011) concludes, science is all around us. According to her study, the use of everyday examples helps learners to differentiate and classify materials and their characteristics, increases the levels of engagement of learners, helps learners to enjoy making links between their different experiences when the curriculum is designed to facilitate such links, and encourages learners to ask questions and hence to understand the concepts better. For example, if you need an acid, you can use vinegar or lemon, or if you need an alkali, there is stomach powder (Eno). This is using easily accessible resources as advocated by Asheela et al. (2015), as a strategy to enhance conceptual understanding.

A paradox exists between teachers' ideas on the use of prior knowledge, with results from research findings (Roschelle, 1995). Teachers focus on the idea that they want learners to have prior knowledge. They believe learners learn first from prior knowledge and then from presented materials (*ibid.*). In addition, they perceive that neglect of prior knowledge, results in learners learning something different from the teachers' intention, no matter how well it is presented. However, the research further finds that learners' prior knowledge confuses teachers' efforts to deliver their intended ideas accurately (Roschelle, 1995). Therefore, this is a challenge especially to teachers of science, because using prior knowledge in science teaching has both advantages and disadvantages.

Svinicki (2006) highlights that prior knowledge can be dangerous sometimes, if it is not correct, due to various cultural beliefs in society. The study maintains that integration of prior knowledge may bring up contradictions and if teachers do not have ways of dealing with such contradictions, this might discourage teachers from incorporating prior everyday knowledge. Prior knowledge also suits specific topics and concepts, but not all. Learners may not always have prior knowledge of some concepts and therefore, teachers must be aware of this and be careful not to consider prior knowledge all the time. This is supported by the research report by Kasanda et al. (2005) who contend that "the nature of everyday context used in class depends to some extent on the topic being taught" (p. 1810). In their study, the teacher used analogies to explain to learners how the rate of reaction depends on the concentration of the reaction. Similarly, I use analogies as a pedagogic strategy to help learners understand and remember concepts during examinations. From my teaching experience, I have learned that it is not always possible to learn without prior knowledge. Prior knowledge influences learning and learners construct concepts from prior knowledge. As educators, we should try to create experiences that engage students in actively making sense of concepts for themselves.

Similarly, like Kuhlane (2011), teachers should consider introducing the topic of 'acids, bases and salts', by first assigning learners to bring to school common household cleaning materials and various types of fruit. Learners could then classify them, by using simple testing methods, into 'acids' and 'bases' (alkalis), respectively. Based on this and using the prior knowledge of elements and compounds, learners can transcend to a better understanding of laboratory acids and bases, such as hydrochloric acid and basic metal hydroxides. In addition, the use of traditional filtration (sieve) and distillation methods are also crucial examples.

A study conducted by Oloruntegbe and Ikpe (2011) on the other hand, found that this might only benefit children from lower socio-economic families since they are involved in assisting parents in the kitchen or garden, unlike those from higher socio-economic families, who may not help parents in domestic work. In their study, they point out that there was little learning and transfer in the sphere of chemical knowledge taught at school that took place with this group of children (*ibid.*).

Science is a complex subject that entails many different aspects of learning, and it is true that learners must be able to link prior knowledge with school science content. However, the preparation for national examinations is not only a challenging time for learners, but for teachers as well. This means that spending more time on everyday life experiences can be a waste of much of the actual time on task in the classroom. Even though it is not assessed, everyday knowledge should be used to access scientific knowledge where possible. The study by Oloruntegbe and Ikpe (2011) also reveals the inability of learners to relate chemistry concepts to home activities due to the pressure of testing at school, as many of the science curricula are not only content based, but also driven by examinations.
It is against this backdrop that the aim of this study is to enhance sense-making of the concept of rates of reactions, through the indigenous practice of making *oshikundu*, a non-alcoholic beverage made in most homes in Namibia.

2.3.5 Indigenous knowledge

Kibirige and Van Rooyen (2006) define indigenous knowledge (IK) as inherited information and practices that are unique to a particular culture. It is established and handed over from one generation to another. In the same vein, Snively and Corsiglia (2001) refer to IK as traditional knowledge (TK), indigenous knowledge systems (IKS) or traditional ecological knowledge (TEK). IK encompasses human experience, which has been modified through practice (Kibirige & Van Rooyen, 2006). IK is confined to a particular culture and is locally bound. Secondly, it can be understood without the use of words. Often, it is passed on orally or by actions and is generally not documented. IK is constantly changing and is linked to the survival of the people (*ibid.*). In addition, IK is holistic and depends on collective knowledge rather than hypothesis and analysis (Shizha, 2007).

Kibirige and Van Rooyen (2006) posit that incorporating IK in teaching and learning makes science more interesting to learners. These authors maintain that the passing on of information from generation to generation, promotes communication. Thus, IK stimulates a communicative approach to education. Furthermore, the exchanges between the elders and the students improve classroom interactions. Lastly, the interaction of IK facilitates starting from what the learner already knows, which makes teaching and learning easier.

IK has similarities with desirable classroom practices (Ogunniyi & Ogawa, 2008). For example, its strong link to everyday life makes it relevant, leading to active participation in classrooms. Secondly, the holistic nature of IK encourages enquiry and allows learners to see that learning is not fragmented (*ibid.*). The authors agree that as the elders recall with enthusiasm their practices, the younger generations learn to respect their traditions. Moreover, it is essential in supplementing western science aesthetically and morally.

Furthermore, IK eliminates the gap between school science and everyday science that causes schools and individual to be dysfunctional (van Wyk, 2002). The study contends that IK can be used to develop higher order thinking skills in a cohesive manner by giving learners an opportunity for construction of knowledge (*ibid.*). For Shizha (2007), learners easily engage with knowledge and use it to develop their societies when teaching is related to their culture. This study proposes that the inclusion of IK in the curriculum helps the young learners to maintain their culture. Le Grange (2007) highly advocates for the integration of western science and IK, whereas, Mukwambo et al. (2014) increasingly call for locally developed programmes to address the development needs of the region. To this end, Mukwambo et al. (2014) realise the benefits of Africanisation in teaching and learning, such as using familiar knowledge to introduce new science concepts and engagement in knowledge construction, in order to achieve a common goal and understanding.

There are several societal benefits from the inclusion of IK in the curriculum. When learners receive education that relates to their culture, they can easily engage with the knowledge and utilise it to develop their societies (Shizha, 2007). In the study carried out in Nigeria to integrate indigenous science with school science for enhanced learning by Erinosho (2013), lack of poor performance and understanding in science subjects was observed in many learners. According to the study, learners often became bored and complained about the difficulties and irrelevancy in comprehending science subjects. The research found that the problem is with abstract science teaching, which is completely out of touch with learners' reality.

Pertaining to the notion above, a science teacher in Grahamstown, engaged community members in her lessons by inviting them to school to give demonstrations of the making and cultural significance of *umqombothi* (sorghum beer) in order to make sense of the demands of the new curriculum that indigenous knowledge be incorporated in science classrooms (O'Donoghue, Lotz-Sisitka, Asafo-Adjei, Kota, & Hanisi, 2007). This is also similar with two projects, the Popular Participation in Curriculum and Instruction (PoPCI) in Ethiopia and the Alaska Rural Systemic Initiative project (ARSI) that have successfully implemented an inclusive curriculum (Erinosho, 2013). The projects were found useful in the sense of allowing learners to value their community knowledge as equivalent to what is taught in schools (*ibid.*).

Despite the positive aspects associated with the inclusion of indigenous knowledge however, lack of documentation and lack of proven scientific procedural explanations and perceptions of western science over indigenous knowledge, are identified as limiting factors in enhancing household food security (Agea, Lugangwa, Obua, & Kambugu, 2008). It is then against this backdrop, that some of these limiting factors may discourage teachers from including IK in the science curriculum. The study by Erinosho (2013) on integrating indigenous science for contextualising school science in Nigerian schools, found that despite its proven effectiveness as a useful pedagogical tool and a good starting point for engaging learners in development issues, there is yet no systemic effort to develop an effective framework for incorporating indigenous science into school science curricula and instruction processes.

Mukwambo et al. (2014) highlight the benefits of Africanisation in teaching and learning, such as using familiar knowledge to introduce new science concepts and engagement in knowledge construction, in order to achieve a common goal and understanding. Their study further expresses that, despite the benefits, there exist some challenges in integrating indigenous knowledge in the science curriculum. They find that it is implicit in nature and is usually accompanied by some myths that are not scientific.

Indigenous knowledge creates some controversy in the debate towards its inclusion in the science curriculum (Kibirige & Van Rooyen, 2006). This study argues that IK cannot be exchanged across cultures and that transferring IK renders it irrelevant, inappropriate and even harmful. Therefore, it is important for teachers to be aware of various cultural indigenous practices, and positively review non-scientific ones, to let learners differentiate between the two based on scientific knowledge, which would then minimise misconceptions. On complexities and challenges related to Africanisation of the school science curriculum, Mukwambo et al. (2014) suggest and "encourage teachers not to avoid such beliefs in the sense making of science, but instead to engage with them" (p. 9). For example, there is a misconception in our society that 'if some people prepare *oshikundu*, it will become bad'. This is not true since either it could be due to a very low or high water temperature used during the preparation process.

The research study by Cocks, Alexander and Dold (2012) reveals the threatening of South African biodiversity. In this regard, the Rio Conventions call for an integrated approach to conservation that incorporates local environmental knowledge and practices. Their study found that the inclusion of indigenous knowledge into the mainstream curriculums could promote conservation as well as cultural revitalisation for indigenous people. According to Cocks et al. (2012), this is very important because it encourages young people to respect their culture and use natural resources wisely (e.g. *Inkcubeko Nendalo*). The study also invites the inclusion of environmental education on biodiversity and cultural heritage to be included in the science curriculum.

2.3.6 Language and science

According to Morrow (2007), there are two kinds of access, namely formal and epistemological access. Formal access deals with barriers that prevent learners from attending schools such as language policies, age restrictions and resources. Epistemological access is about the acquisition of academic knowledge. A study carried out in South Africa that analysed the utterances of three Pietermaritzburg Physical Science teachers (Jawahar & Dempster, 2013) point out that language is characterised as a cause of unequal epistemological access to scientific literacy. As highlighted by Gibbons' (2003) mediation from a sociocultural paradigm, language plays a very important pivotal role in students' learning and is the key to the development of scientific ideas and communication in science.

According to the Namibia National Curriculum for Basic Education [NCBE], Grade 1-3 should be taught in the mother tongue and English should be taught as a subject. The medium of instruction for Grade 4-12 should be English and the mother tongue taught as a subject to accommodate a two-language curriculum. Similarly, the Namibia NCBE (2010) also states that the medium of learning for pre-primary and Grade 1-3 should be the mother tongue. In the case of multi-language schools, the local predominant mother tongue is often used as a medium of instruction. The use of English medium starts in Grade 4, as a transition from the mother tongue. The use of English medium for learning should continue through Grade 5-7 except in some permitted cases, only where assistance can be rendered in the mother tongue. For Grade 8-12, English should be used as a medium except in the national language subject.

In light of the policy, every Grade 4-12 science teacher must use English as a language of learning and teaching (LoLT) in their classrooms. By looking at the Namibian constitution and analysing the curriculum, these sentiments are paradoxical in terms of curriculum expectations and implementation or practice. As advocated by Probyn (2004), Probyn (2009) and Hendricks (2003), schools use English as the language of learning even though it is not the language that learners know and mostly use at home and school. The research studies reveal that this causes tension for science teachers, as they must use learners' mother tongue to make them understand, while adhering to the English language policy of learning.

In the Namibian context, this has become a challenge that most science teachers face when using English as a medium of instruction. As clarified by Kocakulah et al. (2005), some science teachers believe that using English as the only medium of instruction causes less conceptual understanding of science concepts. Therefore, some teachers find it necessary to use learners' mother tongue and to code switch in order to enhance learning, which Probyn (2009) coins as "smuggling the vernacular into the classroom" (p. 123).

Code switching is not always beneficial to learners. According to Jawahar and Dempster (2013) some scientific terms such as work, energy, power and force have different specific meanings in English but would mean the same thing in *isiZulu (ibid.)*. Likewise, the same happens in our culture, because the above terms mean the same in *Oshiwambo*. Hence, code switching can be a problem when teaching and learning Physical Science, if there is no awareness of this issue.

The research study by Kocakulah et al. (2005) on the effect of teaching in native and foreign languages on students' conceptual understanding in science courses, states that: "science is a discipline in which experiential and concrete examples should be presented as an in-class process in order to improve the level of students' conceptual understanding" (p. 21). The research further stipulates that learners have more potential to understand science concepts by using their mother tongue. According to the study, exposing learners to everyday concepts in their mother tongue will also help them comprehend scientific ideas more effectively and make it easier for teachers to diagnose misconceptions amongst learners.

The Namibian curriculum states that children learn best through the medium of their mother tongue (Namibia. NCBE, 2010). In other words, children learn or acquire more knowledge when they are taught in their own language. Therefore, science teachers incorporate learners' mother tongue in classrooms to help learners understand and assimilate the lesson content, even though the Namibian curriculum does not make provision for learners to be taught in another language – this is not the case in South Africa, where the curriculum promotes bi-and multilingualism through an additive approach (Hendricks, 2003).

As proposed by Hendricks (2003), teachers are advised to apply the initiation-response-feedback (IRF) approach in their lessons, in order to promote more classroom interactions between the teacher and learners and between learners themselves. Teachers should also employ Vygotsky's (1978) socio-cultural theory as a framework in teaching, as highlighted in Gibbons (2003). Learners often become bored and complain about the difficulties and irrelevancy in comprehending science concepts. Some researchers find that the problem is with abstract science teaching, which is completely out of touch with learners' reality. It is against this background that Vygotsky's theory appears to be more relevant for cognitive and affective learning in science in this context (Gibbons, 2003). According to the propounded socio-cultural theory, meaningful learning occurs when there is social interaction between learners and those with more experience. In the same vein, language acquisition is required through social sources. It is believed that linguistic skills are learned well, if there is shared thought between beginners [learners] and experienced ones [teachers] (*ibid.*).

The research by Hendricks (2003) posits that using learners' mother tongue in science classrooms, denies learners access to important English language skills, such as communication, reading and writing; therefore, using English only, has both negative and positive effects. Pertaining to that notion, the research study by Kocakulah et al. (2005) indicates that learners who were taught in a foreign language had more misconceptions than those who took the courses in their mother tongue. Therefore "the scientific language which mediates the meanings of the concepts is important and the native language should be preferred for such purposes" (Kocakulah et al., 2005, p. 21). Therefore appropriate strategies to develop English communication, writing and reading skills in science classrooms should be developed.

Based on the study of the interrelation between classroom discourse and learners' learning, Zhang (2008) expresses that learning is closely linked to the quality of classroom discussion. According to this study, teachers should allow more classroom discussion for learners to learn.

2.4 Theoretical framework

A theoretical framework is an important component of a research study. It grounds the study and guides the methodological design. It also forms a reference point for the interpretation of the research findings (Mpofu et al., 2013). According to Imenda (2014), a theoretical framework refers to the theory that a researcher selects to guide him or her in conducting a research project. For Bertram and Christiansen (2015), some types of studies are informed by theories which affect how the data collected should be analysed. The theoretical framework for this study draws from Vygotsky's social-cultural theory.

Socio-cultural theory

Vygotsky's (1978) socio-cultural theory has contributed significantly towards science and science education. Vygotsky believes that construction of knowledge depends on the interdependence of social and individual processes (John-Steiner & Mahn, 1996; McRobbie & Tobin, 1997). These authors submit that Vygotsky emphasises the concept that "human activities that take place in cultural contexts, are mediated by language and other symbol systems, and can be best understood when investigated in their historical development" (*ibid.*, p. 191). According to the propounded socio-cultural theory, meaningful learning occurs when there is social interaction between learners and those with more experience.

Based on the research study on individual and socio-cultural views on learning in science education, Leach and Scott (2003) echo the same sentiments that "learning and meaning making are portrayed as originating in social interactions between individuals, or as individuals interact with cultural products that are made available to them in books or other sources" (p. 93). The research further argues that learners do not only construct scientific knowledge on an individual basis, but also through collaboration with social mediation perspectives. Furthermore, the research study by Aikenhead and Jegede (1999) on cross-cultural science education, reveals the significance of "how students move between their everyday world and the world of school science, and how students deal with cognitive conflicts between those two worlds" (p. 269). According to the study, students experience a shift between students' everyday knowledge and curriculum science [cultural border crossing]. It is maintained that, cognitive conflicts occur due to learners' cultural differences of prior everyday knowledge and curriculum science [collateral learning]. It is therefore against this background that teachers need to employ effective strategies to help learners cross cultural borders with ease, without losing their identity, by considering their existing knowledge, skills and understanding of various science concepts.

In addition, the study by Snively and Corsiglia (2001) insists that science is embedded in our culture [indigenous science] and hence, should be incorporated in the classroom like other sciences. Their research findings highlight the importance of cultural science as fundamental to environmental education and sustainability. Like Aikenhead and Jegede (1999), the best way is to use teaching methods that help learners cross smoothly between cultural science and school science, hence, the choice of the theoretical framework of this study.

2.5 Concluding remarks

The key conceptual framework discussed in the literature points to the value of indigenous knowledge, as prior everyday knowledge, in the learning of science. Practical activities, rates of reactions, sense-making, language and science and the curriculum documents, all point out the use of indigenous knowledge or prior knowledge, as a tool to understanding science concepts. Though indigenous knowledge or prior knowledge creates some challenges, its effective use can improve motivation, enjoyment and attentiveness of learners. In addition, it enables the science classroom to be inclusive by accommodating a variety of perspectives. The proper use of practical activities and language also emerged as key tools in the learning of rates of reactions. These can be used well in an interactive classroom.

The theoretical framework of the socio-cultural theory was discussed and it emerged that meaningful learning occurs when there is social interaction between learners and those with more experience. From a socio-cultural paradigm, language plays a very important role in students' learning and is the key to the development of scientific ideas and communication in science.

The next chapter discusses the methodology used in this study.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the research design and methodological framework that guided the research process of this study. It also describes and discusses the reasons for selecting an interpretive paradigm and mixed-methods approach, in addressing my research questions. It further discusses the sampling, pilot study, data gathering techniques, data collection procedure and analysis processes. The chapter further discusses validity, trustworthiness and issues regarding ethical considerations and ends with some concluding remarks.

The goal of this study was to explore how Grade 11 Physical Science learners make sense of the concept of rates of reactions, through the inclusion of the indigenous practice of making *oshikundu.* To achieve this goal the following sub-questions were explored:

1. What prior knowledge do Grade 11 Physical Science learners have of the concepts related to rates of reactions?
2. How do Grade 11 Physical Science learners make sense of rates of reactions during lessons?
3. How does a practical activity of making *oshikundu* enable or constrain:
   (a) learner engagement?
   (b) making sense of the concept of rates of reactions?

3.2 Research paradigm

The term 'paradigm' refers to ways of viewing the world and conducting research (Bertram & Christiansen, 2015). These authors maintain that, "a research paradigm represents a particular worldview that defines, for the researchers who hold this view, what is acceptable to research and how this should be done" (*ibid.*, p. 22). They posit that, working within a particular paradigm determines choices such as the kind of questions that need to be asked, what is to be observed or investigated, ways of gathering data and how to interpret the results.

In educational research, we focus on three key paradigms: the post-positivism, the interpretivism and the critical paradigm. In post-positivism, the aim of research is to describe, control and predict how the natural and social world works. For interpretivism, the researcher's goal is to describe and understand how people make sense of their world, and how they make meaning of their particular actions. The purpose is to develop a greater understanding of how people make sense of contexts in which they live and work. The critical paradigm sees reality as shaped by social, political, cultural, economic and other dynamics (Bertram & Christiansen, 2015).

Hence, an interpretive paradigm was used with a socio-cultural theory, to study how Physical Science learners make sense of rates of chemical reactions during lessons, using an indigenous practical activity of making *oshikundu*. According to Cohen, Manion and Morrison (2011), the interpretive paradigm views the social world as an emergent social process, which is created by the individuals concerned. Thus, this paradigm allowed me to understand the situation and to interpret meaning within the social and cultural context of the natural setting of this research study, particularly, 'rates of reactions' in Physical Science.

The use of a single approach would not be sufficient to address the aim of this study. Therefore, the study recognises the combination of quantitative and qualitative approaches because it asks both the 'what' and 'how' types of research questions (Cohen et al., 2011). The use of a mixed-methods approach was necessary, as my intention was to understand the different explanations of outcomes, prior to and after the intervention of making *oshikundu*. The goal and theoretical framework also support the use of a mixed-methods approach. Therefore, the study adopted the pragmatic paradigm.

According to Cohen et al. (2011), "pragmatism adopts a methodologically eclectic, pluralistic approach to research, drawing on positivism and interpretive epistemologies based on the criteria of fitness for purpose and applicability, and regarding reality as both objective and socially constructed" (p. 23). Pragmatism suggests that what works well to answer the research question, is the most useful approach to the investigation. For example, be it a combination of experiments, case studies or surveys, combinations enhance the quality of research (Cohen et al., 2011). Hence, a mixed-method approach was used for this study. That is, both quantitative and qualitative data were collected.

3.3 Research methods

This study is a mixed-method case study of the indigenous practice of making *oshikundu*. Cohen et al. (2011) explain that mixed-method research draws on and integrates both numerical (quantitative) and narrative (qualitative) approaches in one study. Similarly, Creswell (2003) describes mixed-method as the approach in which the researcher collects both numeric as well as text data. According to this approach, both open- and closed-ended questions are asked, and both quantitative and qualitative data are collected and analysed sequentially.

In definition, a case study is a specific instance that is frequently developed to show a more general basic idea – the single instance is of a bounded system, for example, a learner, school or community (Cohen et al., 2011). Rule and John (2011) define a case study as an organised plan and in-depth study of a special case in its context. The advantage of a case study is that it can "establish cause and effect and observe effects in real contexts" (Cohen et al., 2011, p. 289). In essence, this is a mixed-method case study, which focuses on promoting the integration of learners' everyday knowledge and experiences with the school science curriculum.

As stated earlier on, whatever works best to answer the research question, is the best approach to the investigation. To this end, question one of this study measured the prior knowledge that learners had of concepts related to rates of reactions. A pre-test was administered to generate quantitative data. Question two aimed at observing how learners make sense of rates of reactions concepts during lessons when the teacher uses the traditional ways of lesson presentations of rates of reactions, whereas, question three aimed at observing how a practical activity of making *oshikundu* enabled or constrained learner engagement and their sense-making of the concept of rates of reactions. A post-test result was conducted and results compared with the pre-test, to find how learners' sense-making shifted as a result of the intervention. Both quantitative and qualitative approaches were employed in answering research question one. A qualitative approach was employed in answering research question two and three. This was carried out through using data gathering techniques such as lesson observations, observation of the practical activity and structured interviews with learners.

Cohen et al. (2011) comment that a mixed-method study adopts different designs. For example, this study used a sequential mixed-method design, in which quantitative and qualitative approaches followed each other, as the research needed. This method used a quan-QUAL sequential design. It is quan-QUAL because qualitative data dominated quantitative during data collection and analysis. It is sequential because the quantitative data were collected and analysed first before the qualitative data.

3.4 Research site and sampling

The research study was conducted in a rural secondary school in the northern part of Namibia. The school was established in 1958 by the Roman Catholic Church and became a government school in 1972. This year [2016], the school's enrolment is 547 learners from Grade 8-12, all from the same cultural and educational background. The school has no hostel accommodation and the majority of learners and teachers walk very long distances to school every day.

The indigenous language of this community, and of all my participants, is *oshimbalantu,* an *oshiwambo* dialect. However, *oshindonga* is selected as the first language at school, while English is their second language and the medium of instruction. Other dialects spoken at school by learners are: *oshingandjera, oshikwaluudhi, oshikwambi, oshikwanyama, oshimbandja* and *oshikolokadhi.*

There were four Grade 11 classes with 95 learners in St. IK Secondary School (pseudonym). It would take too long to test all of them, therefore, I randomly chose one Grade 11 class of 22 learners for this study. Hence, 22 Grade 11 Physical Science learners were participants of this study. The research study involved Grade 11 learners because 'rates of reactions' is covered in year one of the NSSCO Physical Science syllabus. All 22 learners participated in the rates of reactions concept tests, lesson observations and observation of the practical activity of making *oshikundu.* However, only three learners were further selected for the structured interviews. This was based on their academic achievement during the pre-test (average, above average and below average). The class average for the pre-test was 38%. Hence, learners who scored 38% were classified as average learners. In another category, learners who scored less than 38% were classified as below average learners. The other category consisted of those that scored more than 38%. These learners were classified as above average learners, respectively. In my context, I opted for the lowest below learner (L8), average (L7) and highest above average (L16), respectively.

3.5 Data gathering techniques

The main data gathering techniques used were testing, observation and interviews. Cohen et al. (2011) argue that the aim for using different data generation techniques is known as triangulation, which ensures trustworthiness and validity of data collection. Trustworthiness ensures that there is consistency in the findings, even if the enquiry were replicated in the similar context by a different researcher.

3.5.1 Testing

In the interpretive paradigm, testing is used together with other data collection methods, or with the addition of open-ended questions (Bertram & Christiansen, 2015). For this study, testing was administered to the Grade 11 Physical Science class in addition to observations and interviews. As advocated by Bertram and Christiansen (2015), learners were tested before the intervention [pre-test] to ascertain their achievement, and then tested again after the intervention [post-test]. Thus, learners were initially tested on their prior knowledge of processes related to rates of reactions such as corrosion and fermentation that they had learned in Grade 10. A post-test was administered after classroom lessons and the two practical activity sessions to test if learners could now make sense of the concept of rates of reactions. The pre-test and post-test were the same test, but the item questions and choices (possible answers for multiple choice) were rearranged.

I developed the rates of reactions test to measure learners' achievement on rates of reactions, before and after the implementation of the practical activity of making *oshikundu*. The rates of reactions test consisted of 34 items and that represented the conceptual knowledge of the construct. The items comprised of 20 multiple-choice questions and 14 explanatory questions. The post-test was the same as the pre-test, as the tests aimed to capture learners' conceptual knowledge of rates of reactions before and after the learning intervention. The validity of the content of the test on rates of reactions and relevance, were confirmed by two senior lecturers who are experts in the field of chemistry education. They examined the test to make sure that the questions were appropriate to learners. The test was further piloted with Grade 11 Physical Science learners at Good Senior Secondary School (pseudonym) in order to check for language, validity and reliability.

In order to make sense of processes related to rates of reactions, learners were asked to explain the answers for their choices in multiple choice questions (see Appendix 2). However, the majority of learners were unable to explain their choices. They either left a blank space or just re-wrote the question statements.

3.5.2 Observation

When observing, the researcher is an insider to that scene (Bertram & Christiansen, 2015). This means that the researcher goes to the site of the study to obtain first-hand information and to report on what he or she has witnessed, with his or her own senses. Cohen et al. (2011) claim that observational data helps the researcher to generate data from a real situation or context, and thus enables the researcher to engage and comprehend the described situation. The purpose of observation was to explore how learners make sense of rates of reactions. In addition, to explore how the indigenous practical activity of *oshikundu* can be integrated.

After the pre-test, learners were observed over a series of three lessons. Observation was also carried out during a practical activity using worksheets in groups. Lesson observations helped me to understand whether learners made sense of rates of reactions when the teacher used the traditional approach of teaching. Observation of the practical activity helped me to understand whether engaging learners in practical activities, enabled learners to make sense of scientific processes in relation to rates of reactions. The answers in learners' worksheets, served as a tool to support the literature on the practical activities.

Observations were conducted with the whole class during the three lessons as well as the two sessions of the intervention. Observations included watching and listening to learners, as they interacted and engaged with each other (as espoused by the socio-cultural theory informing this study) and watching what they did when completing practical activities. Observation schedules were designed and used when observing learners during lessons and the two practical activity sessions of making *oshikundu*. After the practical activity, I conducted structured interviews with the three sampled learners.

3.5.3 Interviews

An interview is a conversation between the researcher and the respondent (Bertram & Christiansen, 2015). According to Cohen et al. (2011), the research interview is defined as "a two-person conversation initiated by the interviewer for the specific purpose of obtaining research-relevant information" (p. 411). The advantage of interviews is that one can collect much more detailed and descriptive data than through the use of a questionnaire (*ibid.*). The study further highlights that the "interview is a flexible tool for data collection, enabling multi-sensory channels to be used: verbal, non-verbal, spoken and heard" (p. 409).

In a structured interview, the researcher uses an interview schedule, which is a set of questions in a predetermined order. In the open-ended interview, the interviewees express opinions or impressions or are asked to supply some information that will be essentially different from other interviewees' answers (Bertram & Christiansen, 2015). Hence, structured interviews, using open-ended questions, were conducted individually with three (average, above average and below average) learners. Individual interviews were conducted with learners in order to find out how the practical activity (intervention of making *oshikundu*) enabled or constrained learner-engagement and their making sense of the concept of rates of reactions. As advocated by Olakanmi (2015), learners, during their interviews, were asked to use a "think aloud" system to verbalise freely their understanding of the rates of reactions concept (p. 631). The aim was to get into learners' minds and elicit what they were doing and why, as they engaged in the *oshikundu* practical activity.

In total, the interview sessions took about one hour and thirty minutes. All three learners noted that they were not aware of the rates of reactions concept in the making of *oshikundu,* as they had never been taught, using such strategies or approaches. The interviews were transcribed verbatim and this helped me with analysing the data.

3.6 Data collection procedure

Prior to the study, I obtained informed consent from parents to conduct this study. The research study proceeded with learners writing a pre-test in order to reveal their prior knowledge that they had of processes related to rates of reactions. Based on their answers in the pre-test, purposive sampling of learners was conducted to select learners for a structured interview. The first research sub-question was answered from the analysis of the pre-test conducted. After the pre-test, analysis of lesson observations were carried out to answer the second research sub-question. Further observation involving a practical activity of making *oshikundu* were carried out, hence answering the third research sub-question. A structured interview with learners was conducted in order to get more understanding, based on the practical activity of making *oshikundu*. Results from the pre-test and observations informed the planning of the interview. A post-test was then administered after the interview, to test if learners could now make sense of the concept of rate of reaction.

I engaged the Physical Science teacher who taught the three lessons and facilitated the sessions for the intervention of making *oshikundu*. Hence, this involved that the teacher and myself, jointly plan the lessons including the practical activity, which had the benefit of 'two heads are better than one', in its design. It also benefited me to have his contribution to the activity. Furthermore, I was freed up to videotape it and was a little more objective in the analysis.

In our *oshiwambo* culture, making *oshikundu* is the responsibility of the women. Hence, we invited a community woman who was a local expert to demonstrate the practical activity of making *oshikundu*, to learners. The reason for this was that science is embedded in our culture. Since a foreign language can be a barrier to learning (Kocakulah et al., 2005), the presentation was carried out in the native language *oshiwambo*. The advantage was that both the learners and the local expert shared the same mother tongue. After the intervention of making *oshikundu*, we then explained how indigenous science was related to classroom science. The preparation technique of *oshikundu* highlighted factors that affect the rates of a reactions, such as increasing the surface area by crushing *mahangu* and sorghum flour, using hot water (temperature), addition of water (concentration) and of *oshihete* as a catalyst.

3.7 Data analysis

The next step after collecting data is data analysis (Bertram & Christiansen, 2015). Data analysis involves organising, explaining and reducing data, for it to make sense (Merriam, 1998; Cohen et al., 2011). Researchers collect data depending on their research questions. In the context of this study, data were in the form of tests, an interview and worksheet transcripts. In order to find answers to the research questions, data were analysed quantitatively and qualitatively. The analysis process began with quantitative data followed by qualitative data. Both quantitative and qualitative data were compared and contrasted to see how they supplemented each other in answering the research questions, as well as addressing the aim of the study.

3.7.1 Approach to quantitative data analysis

The quantitative data were decoded, interpreted and analysed through the use of statistics which *inter alia* included numbers, percentages, graphs, frequency tables and measures of central tendency (mean average & standard deviation). For this study, descriptive and inferential statistics were used. According to Bertram and Christiansen (2015), descriptive statistics involve finding the average performance and changing data into visual overviews, such as graphs and tables. Hence, I used descriptive statistics because the learners' pre-test and post-test marks were averaged and presented as tables and graphs, in order to summarise the entire set of numbers.

Since, there were four Grade 11 classes with 95 learners in St. IK Secondary School (pseudonym), this would take too long to test all of them (see section 3.4), and therefore, I randomly chose one Grade 11 class of 22 learners for this study. This statistical technique category is known as inferential statistics (Bertram & Christiansen, 2015). The study asserts that inferential statistics are used to make predictions about the similarity of a sample, to the population from which the sample is taken from, for comparison (*ibid.*). It is against this background, that I used inferential statistics to infer the sense-making of learners in the school, from the results of the sample I had actually tested.

3.7.2 Approach to qualitative analysis

Qualitative data analysis interprets data by placing it into themes and categories (Cohen et al., 2011), hence, qualitative data were analysed thematically. Thematic analysis is a method for identifying, analysing, and reporting patterns (themes) within data. Because of its flexibility, thematic analysis is an important method when working with participants as collaborators, and it helps summarise and describe complex findings (Cohen et al., 2011).

The first research sub-question was answered from the analysis of the pre-test conducted. After I had marked the pre-test, I observed lessons and a practical activity of making *oshikundu*. Furthermore, I interviewed three learners in order to get more understanding based on the practical activity. Results from the pre-test and observation of the practical activity, informed the planning of the interview. Herein lies the importance of triangulation and hence validation.

The second and third research sub-questions were answered through analysing data from observations of lessons and of the practical activity, structured interviews and the post-test. The study focused on situations or events that showed or displayed the nature of learner engagement and the making sense of the concept of rates of reactions, during the practical activity of making *oshikundu*. Data generated from observations and the interviews were analysed both inductively and deductively. Based on theory, categories and themes that emerged, the data were then colour coded (Cohen et al., 2011). The reason for coding data was to produce a new understanding that explored similarities or differences across a number of different cases. For instance, during observations, learners' responses that bore scientific explanation [sense making] were analysed. My theoretical framework [socio-cultural theory] was also used as a lens that helped me to analyse concepts such as social interaction and language usage, as informed by this study.

3.8 Validity and trustworthiness

Validity is an important element to research. Research is considered worthless if it is invalid (Cohen et al., 2011). Thus, to ensure validity and trustworthiness in my study, I used various data gathering techniques such as testing, observation and interviews. This method of using several methods is called triangulation. To this end, data were validated through triangulation (mixed-method). According to Cohen et al. (2011), triangulation may be defined as "the use of two or more methods of data collection in the study of some aspect of human behaviour" (p. 195). Therefore, in addition to testing, observation and interviews were employed as data validating techniques.

3.9 Ethical considerations

Researching ethically is very important in analysis, because the researcher is collecting in-depth and sometimes personal information (Bertram & Christiansen, 2015). To this end, participants' rights were respected and protected. In addition, participants had full autonomy to question the research that I was conducting, to participate freely and withdraw at any time. Prior to the study, I sought permission from the Regional Director of Education for approval in order to carry out the study at St IK Secondary School (pseudonym). I used pseudonyms to make sure that the identities of my participants were not disclosed. Secondly, I obtained consent letters from parents of learners involved, including permission to take recordings and photographs.

3.10 Concluding remarks

In this chapter, I described the research paradigm underpinning this study and research methodological framework. The research goal and questions were outlined and research site described. Sampling procedures and data gathering techniques such as analysis of tests, observation and interviews were also discussed. The validation process was done through triangulation. Ethical issues included anonymity to respect and protect the rights of research participants.

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

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND DISCUSSION

4.1 Introduction

The main goal of the study was to explore how Grade 11 Physical Science learners make sense of the concept of rates of reactions, through the inclusion of the indigenous practice of making *oshikundu*. In this chapter, I thus present, analyse and discuss quantitative data sets derived from the pre-test and post-test. Quantitative data were analysed through the use of frequency tables and graphs. In my discussion, I linked the findings to the literature reviewed in Chapter Two. The aim was to answer the first research sub-question:

1. What prior knowledge do Grade 11 Physical Science learners have of the concepts related to rates of reactions?

4.2 Presentation of quantitative results

Prior to gathering data for this study, I administered a pre-test, before the lesson observation on the theory of rates of reactions and an intervention in the form of a practical activity of making *oshikundu* to Grade 11 Physical Science learners, in order to establish the prior knowledge that these learners had of concepts related to rates of reactions. After five days, a post-test was then administered. The post-test was administered after the intervention, to establish if the intervention enabled the learners to make sense of the concepts related to rates of reactions or not. All 22 learners in the Physical Science class were used for the analysis of quantitative data (see Section 3.4). The results from the pre-test and post-test are shown below.

Table 4.1: Results of the pre-test, post-test and the shifts (variances) in the tests

Learner	Pre-test	Post-test	Shift
Learner 1 (L1)	33	73	+40
Learner 2 (L2)	42	71	+29
Learner 3 (L3)	36	78	+42
Learner 4 (L4)	24	53	+29
Learner 5 (L5)	44	76	+32
Learner 6 (L6)	27	58	+31

Learner 7 (L7)	38	51	+13
Learner 8 (L8)	18	67	+49
Learner 9 (L9)	31	76	+45
Learner 10 (L10)	44	64	+20
Learner 11 (L11)	47	67	+20
Learner 12 (L12)	40	80	+40
Learner 13 (L13)	31	69	+38
Learner 14 (L14)	36	71	+35
Learner 15 (L15)	29	73	+44
Learner 16 (L16)	62	91	+29
Learner 17 (L17)	42	73	+31
Learner 18 (L18)	60	76	+16
Learner 19 (L19)	20	67	+47
Learner 20 (L20)	27	40	+13
Learner 21 (L21)	62	80	+18
Learner 22 (L22)	42	71	+29
Total	**835**	**1525**	**+690**

The results from the table above showed that each learner performed poorly in the pre-test compared to the post-test, as evidenced by the positive shift. The positive overall shift of the score (690) showed that learners attained some knowledge after the intervention, as indicated by the overall post-test score (1525). However, it could be argued that the good performance in the post-test might be attributed to classroom teaching that learners also had on the theory of rates of reactions before the intervention (practical activity of making *oshikundu*). To that end, it is possible that not all the positive shifts be attributed to the practical activity of making *oshikundu.* Despite the poor performance however, at least these learners had some prior knowledge of concepts related to rates of reactions.

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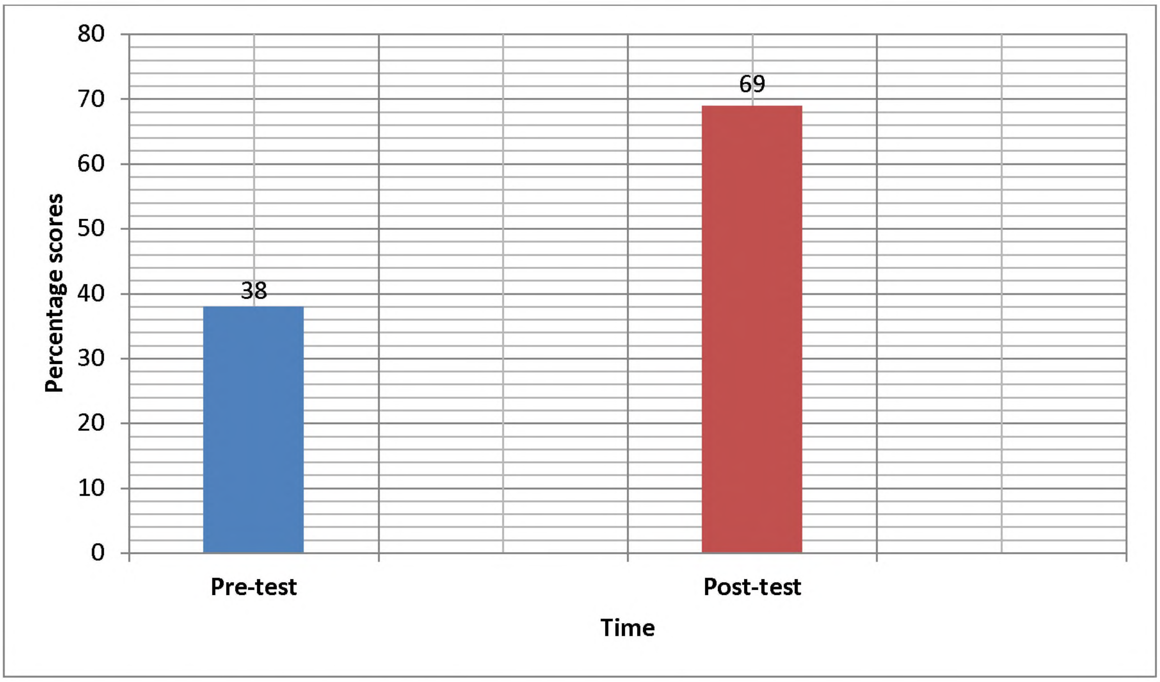

Figure 4.1: Average percentage scores for the pre-test and post-test

The results in Figure 4.1 show that the average performance for the pre-test (38%) is less than the post-test (69%), with a difference of 31% (shift). Though most learners performed below average (38%) in the pre-test, the high performance of those above average, could be because some learners were repeating Grade 11. In other words, when the pre-test was administered, these learners knew something about rates of reactions already.

The learners' performance was further analysed to show the performance of each learner in the pre-test and post-test. The following graph shows the performance analysis of each learner in the pre-test and post-test.

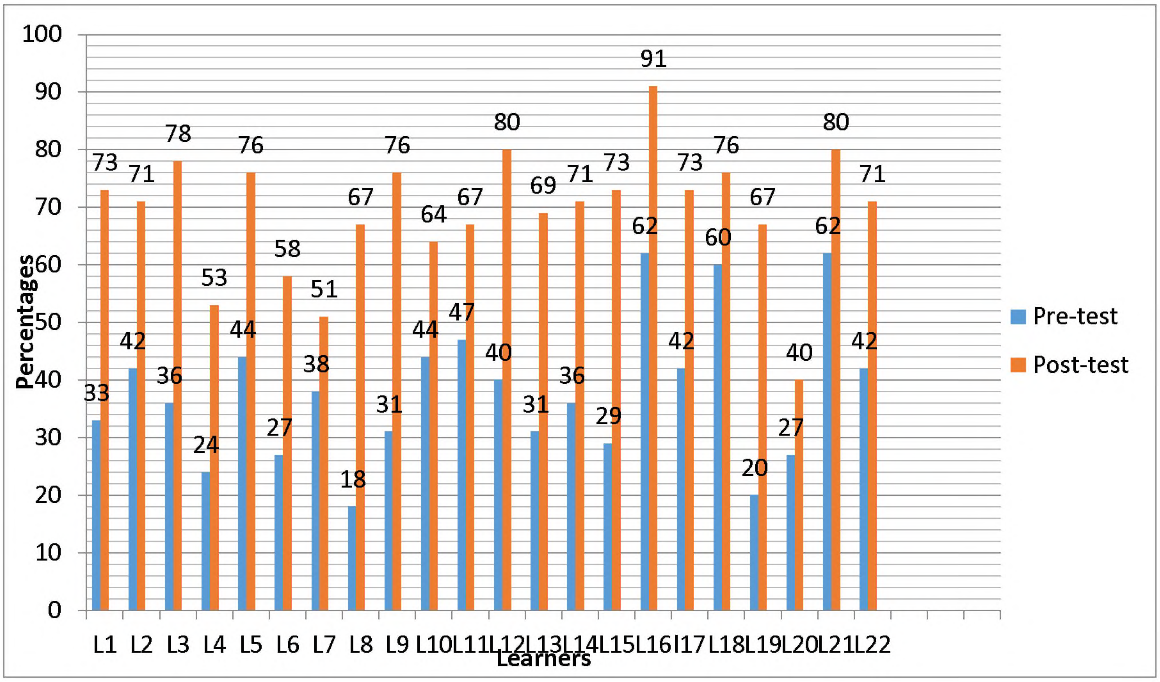

Figure 4.2: Pre-test and post-test results for each learner

As can be seen in Figure 4.2 above, each learner's post-test result is greater than the pre-test. In the pre-test, 10 learners (45%) scored above the average of 38%. In contrast, 13 learners (59%) scored above the average of 69% in the post-test. These results suggested that the integration of teaching the theory of rates of reactions, with the intervention of making *oshikundu,* positively increased learners' sense-making of the concepts related to rates of reactions.

Table 4.2: Detailed learners' scores of rate of reaction concepts per item

Item number	Item and code	Pre-test	Post-test
A1	Definition of rate (DR)	8/22	1/22
A2	Temperature of reaction (TR)	20/22	22/12
A3	Catalyst (C)	19/22	22/22
A4	Theories (T)	6/22	14/22
A5	Nature of substance (NS)	10/22	14/22
A6	Theories (T)	13/22	16/22
A7	Theories (T)	16/22	17/22
A8	Temperature of reaction (TR)	8/22	10/22
A9	Activation energy (AE)	9/22	13/22
A10	Theories (T)	14/22	21/22

A11	Graphs and calculations (GC)	13/22	13/22
A12	Concentration of reaction (CR)	16/22	21/22
A13	Theories (T)	13/22	16/22
A14	Theories (T)	5/22	8/22
A15	Concentration of reaction (CR)	3/22	9/22
A16	Catalyst (C)	19/22	22/22
A17	Theories (T)	15/22	20/22
A18	Graphs and calculations (GC)	9/22	17/22
A19	Catalyst (C)	3/22	2/22
A20	Catalyst (C)	21/22	22/22
B1a	Surface area (SA)	3/22	16/22
B1b	Temperature of reaction (TR)	7/22	14/22
B1c	Surface area (SA)	1/22	12/22
B1di	Temperature of reaction (TR)	21/22	19/22
B1dii	Surface area (SA)	0/22	14/22
B2a	Graphs and calculations (GC)	10/22	20/22
B2b	Graphs and calculations (GC)	11/22	21/22
B2c	Theories (T)	4/22	15/22
C1a	Graphs and calculations (GC)	16/22	22/22
C1b	Theories (T)	10/22	19/22
C1c	Graphs and calculations (GC)	11/22	22/22
C1d	Graphs and calculations (GC)	8/22	21/22
C1e	Graphs and calculations (GC)	10/22	20/22
C1f	Theories (T)	2/22	12/22

4.2.1 Definition of rates of reactions

In defining the rate of a chemical reaction, eight learners (36%) indicated that the rate of a chemical reaction can be expressed in volume of gas per minute. The pre-test result showed that 14 learners (64%) misunderstood the definition of rate of reaction, however, in the post-test 16 learners (73%) defined rate of reaction correctly.

4.2.2 Graphs and calculations (GC)

In the pre-test, learners were presented with different graphs where they had to draw and carry out calculations as well as deducing answers from them. There were eight items [two multiple choice (A11 and A18) and six structured (B2a, B2b, C1a, C1c, C1d and C1e)] that assessed learners' prior knowledge on working with graphs and calculations.

A11: The results showed that 13 learners (59%) selected rate as a 'change in concentration over unit time elapsed' in both the pre-test and post-test, therefore there was no shift in results in the post-test.
A18: In the pre-test, nine learners (41%) selected the correct time when the reaction stopped. In the post-test, 17 learners (77%) selected the correct answer in this multiple-choice question. This meant that there was an increase in conceptual understanding in carrying out calculations from tables.

For the six short answers or explanatory items, the results were as follows:

B2a: 10 learners (45%) were able to state correctly the time at which the reaction stopped, with reference to the graph. In the post-test, 20 learners (91%) stated the correct answer for this item.
B2b: In the pre-test, 11 learners (50%) were able to calculate the average rate of a reaction correctly, whereas, the post-test result showed that 21 learners (95%) were able to.
C1a: In the pre-test, 16 learners (73%) balanced the equation for the reaction between magnesium and hydrochloric acid correctly, by counting the number of atoms on both sides of the reaction (reactants and products). In the post-test, all 22 learners (100%) were able to balance the equation correctly.
C1c: For this item, 11 learners (50%) were able to sketch and label correctly the graph at given variables in the pre-test (reaction A). As above, all 22 learners increased this competency to a 100% score in the post-test.
C1d: For this item, eight learners (36%) predicted correctly the shape of the graph (reaction B) when the same experiment was repeated, but at a higher temperature. In the post-test, 21 learners (95%) drew a graph with a steeper curve correctly.
C1e: By deducing answers from the graph in C1c and C1d above, 10 learners (45%) were able to give the reasons for the reaction that was faster. They indicated that reaction B was faster

than reaction A because at a higher temperature, the particles gain more kinetic energy and thus more successful collisions occur, increasing the rate of a reaction. Hence, curve B is steeper than curve A. For the post-test, 20 learners (91%) were able to answer this correctly.

4.2.3 Theories (T)

There were seven multiple-choice items (A4, A6, A7, A10, A13, A14 and A17) and three structured items (B2c, C1b and C1f) on theories of rates of reactions.

A4: The results showed that only four learners (18%) knew that ethanol and carbon dioxide are formed during the fermentation of glucose. This result was higher in the post-test with 14 learners (64%) selecting the correct answer for this item.
A6: The results indicated that 13 learners (59%) were able to spot the change, which increased the rate of a reaction, for the reaction between limestone and hydrochloric acid. They selected that increasing the concentration of the acid increases the rate of the reaction. In the post-test, 16 learners (73%) selected the correct answer for this item.
A7: A total of 16 learners (73%) indicated that as the frequency and the number of effective collisions between reacting particles increase, the rate of the reaction also increases. However, this result only slightly shifted during the post-test, with 17 learners (77%) selecting the correct answer.
A10: This item assessed the prior knowledge that learners had on corrosion of metals. For this item, 10 learners (45%) indicated that discarded iron objects rust (corrode) faster at coastal areas. The results of the post-test showed that 21 learners (95%) selected the correct answer.
A13: This item assessed the theories of the factors that affect the rate of a reaction. For this item, 13 learners (59%) selected that the rate of a reaction is influenced by the surface area, temperature and concentration of the reaction. Sixteen learners (73%) selected the correct answer in the post-test.
A14: On the question of 'how rates of reactions change with time', only five learners (23%) could select that 'the rates decrease'. In contrast, 12 learners (55%) selected the wrong option, which states that 'the rates increase'. This item was still poorly understood in the post-test, with only eight learners (36%) circling the correct answer.
A17: On the theory of collision of particles, 15 learners (68%) provided that in order for particles to react, the particles must collide. In the post-test, 20 learners (91%) provided the correct answer for this item.

B2c: Learners performed poorly in the pre-test. Of the 22 learners who sat for the pre-test, only four learners (18%) suggested that the rate of a reaction decreases as the reaction proceeds, which is because the reaction comes to an end (the reactants are used up). However, they performed better on this item in the post-test. Fifteen learners (68%) suggested the correct reason for this.

C1b: On the prior knowledge about the theory of writing chemical equations in words, 10 learners (45%) correctly wrote the words for the reaction between magnesium and hydrochloric acid in the pre-test. In the post-test, 19 learners (86%) wrote the word equation correctly.

C1f: This item enquired about the mass of magnesium used, if the volume of hydrogen produced is the same in each experiment (reaction A and B). For this item, only two learners (9%) could explain that the same mass of magnesium will give the same volume of hydrogen, whether the reaction is slow or fast. This result increased in the post-test, where 12 learners (55%) gave correct explanations.

4.2.4 Nature of substance (NS)

For the item on the effect of the nature of substances on the rate of a reaction, 10 learners (45%) scored in the pre-test and 14 learners (64%) in the post-test.

4.2.5 Activation energy (AE)

When learners were asked about the phrase 'the minimum amount of energy required starting a chemical reaction' in a multiple-choice question, nine learners (41%) selected the correct answer which is 'activation energy'. Their performance increased further with 13 learners (59%) answering correctly in the post-test.

4.2.6 Temperature (TR)

In terms of the effect of temperature on the rate of a reaction, there were two multiple-choice items (A2 and A8) and two explanatory items (B1b and B1di).

A2: For the first item, 20 learners (91%) selected that in a chemical reaction, if the reactants are heated, the reaction usually happens faster. For the post-test, all 22 learners (100%) selected the correct answer.

A8: In the second item, eight learners (36%) selected the correct answer, that in an effort to speed up a reaction, one would not cool the reaction down. For the post-test, 10 learners (45%) selected the correct answer for this item.

B1b: Based on the factors that affect the rate of a reaction, learners were asked to explain why food does not spoil as fast when it is refrigerated, as it would at room temperature. A total of seven learners (32%) explained that 'the low temperature in the refrigerator slows down decomposition reactions; hence, a reaction goes slower'. This score was higher in the post-test with 14 learners (64%) explaining correctly.

B1di: For another item, learners were further asked to explain why *oshikundu* does not ferment faster during winter. Pertaining to this, 21 learners (95%) explained that it is 'due to a lower temperature that slows down the fermentation processes' in the pre-test. In the post-test, 19 learners (86%) explained correctly.

4.2.7 Surface area (SA)

There were three explanatory questions measuring the conceptions related to the effect of surface area on the rate of a reaction (B1a, B1c and B1dii).

B1a: On the first item of why iron fillings would rust faster than an iron nail, only three learners (14%) explained that the rate of a reaction increases when the surface area of a solid reactant is increased as shown by the pre-test result. These learners talked about the fact that the surface area of iron increases as it is broken up into small bits. For most learners, they did not realize that the nail and the iron filings were made of the same substance, whereas in the post-test, there were 16 learners (73%) who explained correctly.

B1c: For the second item of why meat spoils less rapidly when left unsliced, only one learner (5%) could give the correct explanation that 'the reaction will go slower because the unsliced meat has a small surface area'. However, the post-test result was higher with 12 learners (55%) giving correct explanations.

B1dii: For the third item – why is there a danger of explosions in places such as silos and coalmines, where there are large quantities of powdered, combustible materials – there was no learner (0%) who could state that it was due to a greater surface area of the powdered materials. However, the score for this item increased in the post-test where 14 learners (64%) gave correct explanations for the item.

4.2.8 Concentration (CR)

There were two multiple-choice items (A12 and A15) for the effect of concentration on rates of reactions.

A12: For the first item, 16 learners (73%) selected the correct answer in the pre-test. While for the post-test 21 learners (95%) selected the correct answer – 'if the concentration of reactants is higher, the reaction rate is higher'.

A15: For the second item, only three learners (14%) selected the correct answer in the pre-test. In the post-test, however, nine learners (41%) selected that 'changing the pressure of a gas is another way of changing the concentration of the reaction'. This result showed that learners had more prior knowledge of the first item than the second item.

4.2.9 Catalyst (C)

There were four multiple-choice items (A3, A16, A19 and A20) about the effect of catalysts on rates of reactions.

A3: During the pre-test, 19 learners (86%) selected that the main purpose of a catalyst is to speed up the reaction. All 22 learners (100%) in the post-test excellently answered this item.

A16: In the preparation of *oshikundu*, 19 learners (86%) indicated that *oshihete* (residue from already fermented *oshikundu*), is added to the mixture because it acts as a catalyst and speeds up the rate of the fermentation process. As in A3 above, all 22 learners (100%), gave the correct answer in the post-test. This result showed that learners had more prior knowledge and experience of making *oshikundu*. They also connected the role of the addition of *oshihete* to *oshikundu* to the work of a catalyst. This was integration of every day prior knowledge and experiences, with curriculum science.

A19: There were only three learners (14%) in both the pre- and post-test who selected the correct answer – that catalysts generally affect chemical reactions by 'providing an alternative pathway with lower activation energy'.

A20: 21 learners (95%) impressively answered this question on the work of enzymes as biological catalysts on the rate of a reaction, correctly in the pre-test. All 22 learners (100%) answered correctly in the post-test. These results indicate that learners had prior knowledge of the work of catalysts in their everyday life situations.

The pre-test results showed that learners had less prior knowledge in the topic of surface area compared to other topics, such as temperature and the effect of catalysts on a rate of reaction. Moreover, the score for all items were further analysed to determine the overall performance of each concept involved in rates of reactions, under the topics column in Table 4.3 below.

Table 4.3: Percentages of learners' scores of rates of reactions concepts per topic

Topic(s)	**Pre-test**	**Post-test**	**Shift**
Definition of rates of reactions (DR)	36	73	+37
Graphs and calculations (GC)	50	89	+39
Theories (T)	45	72	+27
Nature of substance (NS)	45	64	+19
Activation energy (AE)	41	59	+18
Temperature (T)	64	74	+10
Surface area (SA)	6	64	+58
Concentration (CR)	43	68	+25
Catalyst (C)	70	77	+7
Total	**400**	**640**	**+240**

The pre-test results in Table 4.3 show that learners obtained high scores for the topics of graphs and calculations (50%), the effect of temperature (64%) and the effect of catalysts (70%). Learners obtained lower scores for the topics of the effect of surface area (6%), definition of rates of reactions (36%), the effect of activation energy (41%), the effect of concentration (43%), the effect of nature of substance (45%) and the theories of rates of reactions (45%).

However, after the intervention, the learners obtained the highest percentage scores and shift (change) for the effect of surface area (64 and 58), graphs and calculations (89 and 39), definition of rates of reactions (73 and 37), theories (72 and 27) and the effect of concentration (68 and 25).

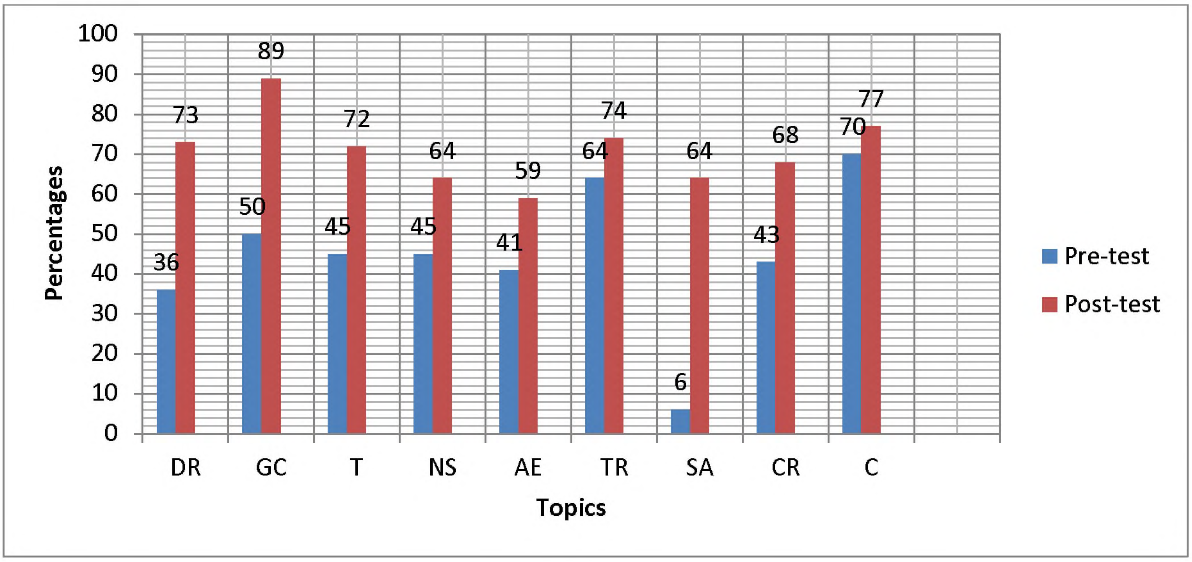

Figure 4.3: Comparison of the pre-test and post-test results for each topic

Figure 4.3 reveals a significant difference in performance between the pre-test and post-test in the different topics of rates of reactions concepts. This result suggests that the practical activity (intervention of making *oshikundu*) increased learners' understanding of concepts related to rates of reactions. The analysis revealed that there was a significant shift in the total of the test scores of the pre-test and post-test for each topic. The result further showed that the intervention had a positive effect on learners' achievement in the understanding of the concept of rates of reactions.

In statistical calculations, it is important to describe how a set of data is distributed (Bostock, Chandler, Shepherd & Smith, 1992). For example, the distribution of the mark scores of 22 learners could be described by a value representative of the most scores (an average value), together with an indication of how far the mark scores are spread about this value (standard deviation).

Table 4.5: Mean and standard deviation of pre-test and post-test

Time	**Mean ($\bar{x}$)**	**Sample Standard deviation (STDEV.S)**
Pre-test	38	12.37
Post-test	69	11.11

The analysis in Table 4.5 reveals that there was a difference between the pre-test and post-test scores. As can be seen from Table 4.5, the mean scores were 38 for the pre-test and 69 for the post-test, respectively. Therefore, there was strong evidence that, on average, the intervention of making *oshikundu* lead to improvements.

Before the intervention, the sample standard deviation for the pre-test score was 12.37. However, after the intervention, the sample standard deviation for the post-test score was 11.11 less than the pre-test. The lower sample standard deviation (11.11) meant that learners' responses were close to the mean average during the post-test compared with the pre-test. This means that learners performed better in the post-test than the pre-test.

4.3 Discussion of quantitative data

Prior to the implementation of the practical activity (intervention of making *oshikundu*) on rates of reactions, the learners obtained high scores (50% and above) for the topics of graphs and calculations, the effect of temperature and the effect of catalysts. The higher scores may have arisen because these learners had learned about the effect of temperature and catalysts during the teaching of fermentation in life science and biology. They may also have learned about corrosion of metals and factors that speed up the corrosion process in previous grades. These findings concur with Roschelle (1995), who postulates that learning starts firstly from prior knowledge, and only later from the presented materials, as learners possessed some knowledge of rates of reactions before the topic was introduced to them.

Learners obtained low scores (below 50%) for the topics of the effect of surface area, definition of rates of reactions, the effect of nature of substance, the effect of concentration, the effect of activation energy and the theories of rates of reactions. These findings are similar to those of Supasorn and Promarak (2015) and Yalcinkaya et al. (2012) who conclude that rate of chemical reactions is one of the most difficult topics to understand because it involves numerous calculations and is also due to many factors that affect the rate of a reaction. In Yalcinkaya et al.'s (2012) study, they advocate case-based learning (CBL), which is a teaching method of teaching learners the concepts based on the cases of their everyday life. These cases are associated with real-life events that would help link learners' prior knowledge with new information. Their approach is similar to the practical activity of making *oshikundu* in the context of this study.

Notably, after the intervention, the learners obtained the highest percentage scores and shift (change) for the effect of surface area, definition of rates of reactions, graphs and calculations, theories and the effect of concentration. These high shifts occurred because during the time between the pre-test and post-test, the learners were studying the topic of rates of reactions in detail. In addition, learners had access to additional instructions and completed additional work before the post-test. Furthermore, as alluded to by Olakanmi (2015), this was also because learners were provided with an opportunity that involved hands-on activities that engaged with collaborative or interactive learning settings, that helped them relate rates of reactions concepts to everyday life. The practical activity that I used in these topics (varying conditions of making *oshikundu*) was perfectly matched to the target concepts (factors that speed up the rate of a reaction). As advocated by Chairam et al. (2009), with the use of experiments, learners are able to explain the changes in the rate of a reaction. In fact, the practical activity gave them a better understanding of the concept of rates of reactions.

Additionally, the lowest pre-test percentage score was in the topic of surface area, possibly because learners had very little knowledge about the effect of surface area on a rate of reaction. The pre-test results revealed that all learners misunderstood why iron filings rust faster than an iron nail. Only three learners (14%) could explain that the rate of a reaction increases when the surface area of a solid reactant is also increased (see Appendix 2). In contrast, the post-test results showed that 16 learners (73%) provided correct explanations that an object or substance with a larger surface area reacts faster. However, there were still six learners (27%) who did not answer this question correctly – they thought that iron filings have a smaller surface area than an iron nail – which is incorrect, as the surface area increases when a substance has been crushed into powder. For this reason, there is the danger of explosions in places such as silos and coalmines, where there are large quantities of powdered, combustible materials. Even so, the result showed a very big shift of 58%. This reveals similar results with the study carried out in Turkey by Calik et al. (2010) on the effect of conceptual change pedagogy on students' conceptions of rates of reactions. As posited above, to an extent, the intervention of making *oshikundu* might help learners to overcome their misconceptions and to keep their newly structured knowledge in their long-term memories. The results indicated that in the post-test, the learners achieved better results on the rates of chemical reactions concepts, compared to the pre-test. The results of this study thus suggest that the teaching intervention used here resulted in conceptual development that is subsequently stored in the learners' long-term memory (Calik et al., 2010).

4.4 Concluding remarks

This chapter provided the presentation, analysis and discussion of quantitative data from the pre-test and post-test using literature reviewed in Chapter Two. The findings of the study revealed that learners had some prior knowledge of concepts related to rates of reactions, such as food storage, fermentation of *oshikundu* and corrosion processes.

In the next chapter, I present, analyse and discuss qualitative data from observation of lessons, observation of the practical activity of making *oshikundu,* as well as individual interviews with learners.

CHAPTER FIVE

DATA PRESENTATION, ANALYSIS AND DISCUSSION

5.1 Introduction

In this chapter, I present, analyse and discuss qualitative data from observation of lessons, observation of the practical activity (intervention on making *oshikundu*) and individual interviews with learners. In order to analyse qualitative data, I developed themes in relation to the data as well as the research sub-questions described in Chapter Three. Hence, I would be able to answer the second and third research sub-questions:

2. How do Grade 11 Physical Science learners make sense of rates of reactions during lessons?
3. How does a practical activity of making *oshikundu* enable or constrain:
   (a) learner engagement and
   (b) sense-making of the concept of rates of reactions?

In my discussion, I also link the findings to the literature reviewed in Chapter Two.

5.2 Qualitative results

Data from the observation of lessons and observation of the practical activity with 22 learners, were analysed. As described in Section 3.4, in addition to observations, three Grade 11 Physical Science learners were purposively selected as participants for interviews for this study. This was based on their academic achievement during the pre-test (average-38%, above average-more than 38% and below average-less than 38%). Eleven learners scored below average between 0% and 38%. One learner scored 38% (average learner). The other ten learners scored between 38% and 100%. These were above average learners.

After checking for similarities and differences from the observation, interviews and worksheet marked texts, data categories were constructed. The categorised data was then reduced to ten preliminary sub-themes as shown in Table 5.1 below.

Table 5.1: Generating sub-themes from description of marked text

Description of marked text	**Sub-themes**	**Data source**
Cultural experience/cultural knowledge/traditional roles and norms	Indigenous knowledge Socio-cultural interaction	Interview
Building on existing knowledge/own knowledge and experience/knowledge from home/everyday examples	Learners prior ideas and experience	Interview Observation
Doing practical activity/practical activity enhance understanding/hands-on experience	Hands-on experience	Interview Observation
Knowledge with understanding/knowledge recall/learning new things/sense-making	Construction of knowledge	Interview Observation
Linking science to everyday life/relationship between home science and school science	Integrating prior experiences with school science	Interview Worksheet
Testing hypothesis/making predictions/learners' explanations/drawing conclusions	Meaningful learning	Interview Observation Worksheet
Teaching others/learning from others/learning together/group work	Cooperative or collaborative learning	Interview Observation
Misconception about science/perception about science/*oshikundu* making is not science	Misconception and perception about science	Interview Observation
Codes switching/translation	Language usage	Observation
Active learning strategies/effective interaction/active participation	Social interactions Learner-engagement	Interview Observation

Thereafter, I combined common sub-themes to form themes. Hence, three main themes emerged on how a practical activity of making *oshikundu* enabled learner engagement and sense-making of the concept of rates of reactions.

The three themes are:

- Instructional method as way of fostering and monitoring learners' understanding;
- Connection between classroom science and prior experiences in and out of school; and
- Sense-making of the intended scientific ideas and concepts.

The three themes are described with supporting theory/literature as shown in Table 5.2 below.

Table 5.2: Themes and supporting theory/literature

Themes	**Theory/literature**
Theme 1: Instructional method as a way of fostering and monitoring learners' understanding	
Hands-on experience; Cooperative or collaborative learning; Social interactions; Learner-engagement.	Vygotsky (1978); Hodson (1990); Gott and Duggan (1996); Maselwa and Ngcoza (2003); Woodley (2009); Millar (2010).
Theme 2: Connection between classroom science and prior experiences in and out of school	
Indigenous knowledge; Socio-cultural interaction; Learners prior ideas and experience; Integrating prior experiences with school science.	Vygotsky (1978); Roschelle (1995); Aikenhead and Jegede (1999); Snively and Corsiglia (2001); van Wyk (2002); Leach and Scott (2003); Stears et al. (2003); Strangman and Hall (2004); Kasanda et al. (2005); Kibirige and Van Rooyen (2006); Svinicki (2006); Le Grange (2007); O'Donoghue et al. (2007); Shizha (2007); Agea et al. (2008); Ogunniyi and Ogawa (2008); Kuhlane (2011); Oloruntegbe and Ikpe (2011); Rennie (2011); Erinosho (2013); Mukwambo et al. (2014); Asheela et al. (2015).
Theme 3: Sense-making of the intended scientific ideas and concepts	
Construction of knowledge; Meaningful learning; Misconception and perception about science; Language usage.	Gibbons (2003); Hendricks (2003); Probyn (2004); Kocakulah et al. (2005); Morrow (2007); Zhang (2008); Probyn (2009); NCBE (2010); Jawahar and Dempster (2013).

I now discuss each of these below.

5.2.1 Instructional method as a way of fostering and monitoring learners' understanding

The theory of rates of reactions was taught through using the traditional way of teaching. The lessons were aimed at exploring how Grade 11 Physical Science learners make sense of rates of reactions during lessons. Hence, learners were engaged in group work activities where they shared ideas. For example, learners were involved in writing down the basic competencies with the teacher on the chalkboard. In addition, they also carried out a group work activity, on the factors that affect the rates of reactions by using computer diagrams.

As shown below, if the solid is split into several pieces, the surface area increases. What effect will this have on rates of reactions?

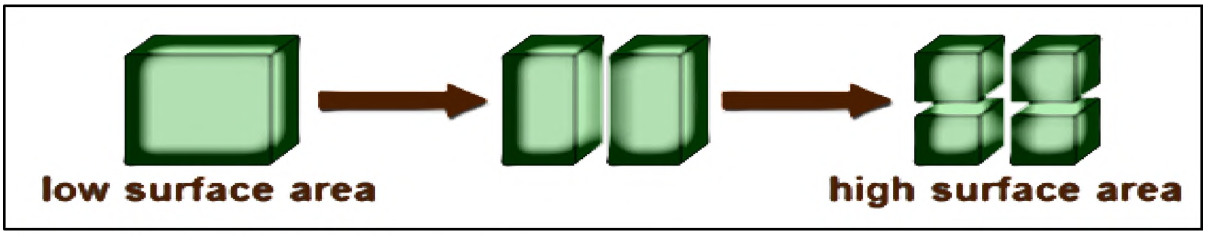

Figure 5.1: Particle size and surface area

This means that there is an increased area for the reactant particles to collide with one another. The smaller the pieces, the larger the surface area. This means more successful collisions result in a greater chance of a reaction.

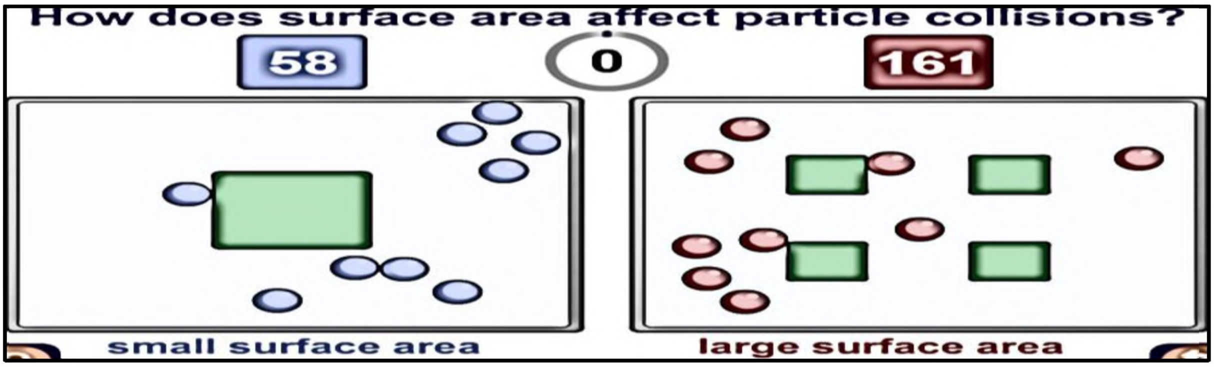

Figure 5.2: Surface area and particle collisions in 5 minutes

Figure 5.2 shows that there are less collisions when the surface area is small, and more collisions when the surface area is large. This reaction shows that there were 58 collisions made when the surface area is small. However, there were 161 collisions made when the surface area is large at constant time. Furthermore, the lesson activities allowed learners to talk to one another. Thus, learners were motivated to answer the teacher's questions with reference to models or diagrams (Woodley, 2009). Apart from surface area, similar diagrams were also used to explain the effect of concentration, temperature and the effect of addition of a catalyst.

During the intervention, opportunities were provided for learners to build on their present understanding as they developed new understanding by carrying out the practical activity of making *oshikundu.*

Figure 5.3: Preparation and making of oshikundu with a community woman

The aim of this activity was for learners to explore how the making of *oshikundu* enabled or constrained learner-engagement and sense-making of the concept of rates of reactions. In addition to the knowledge and experience gained from the practical activity of making *oshikundu* with the community woman, learners experienced these concepts further through doing practical activities themselves in the classroom, where they investigated factors that affect the rate of a reaction.

Figure 5.4: Learners carrying out practical activity of oshikundu in the science laboratory

According to Gott and Duggan (1996), a practical activity has a key role in the teaching of evidence, provided that the type of practical activity is selected carefully with a clear purpose in mind. Hence, in this study I used the making of *oshikundu* as an example in Physical Science to enable learners to understand the concept of rates of reactions. *Oshikundu* is a commonly respected traditional *oshiwambo* drink prepared by crushing *mahangu* grains into flour, adding hot water, stirring and then letting it cool. Sorghum flour (natural sugar) is also added and then put in a clay container with *oshihete* (residue of ready fermented *oshikundu*) for it to get ready to drink. This process uses easily accessible resources as advocated by Asheela et al. (2015), as a strategy to enhance conceptual understanding. The preparation technique highlights the factors that affect the rate of a reaction, such as increasing the surface area by crushing *mahangu* and sorghum grains, using hot water (temperature) and addition of *oshihete* as a catalyst.

During the intervention, we inserted balloons into *oshikundu* in containers at different concentrations and temperatures and those containers with and without *oshihete*. The six plastic bottles were each covered with a balloon tightly tied on the mouth of the bottle (see Figure 5.4 above).

The learners were rearranged in five groups where each group had to follow the procedures given in the experiment worksheet (see Appendix 4), and they then had to discuss the questions and write answers in the worksheet.

Table 5.3: Description labels on plastic bottles

Pair	**Experiment**	**Control**
Pair A	*Oshihete* added	No *oshihete* added
Pair B	Indoor *oshikundu*	Outdoor *oshikundu*
Pair C	Undiluted *oshikundu*	Diluted *oshikundu*

As shown by Table 5.3 above, six plastic bottles: Pair A (*oshihete* added & no *oshihete* added), Pair B (indoor *oshikundu* & outdoor *oshikundu)*, and Pair C (undiluted *oshikundu* & diluted *oshikundu)* were each filled with *oshikundu* as per description labels above. In each pair, one container acted as an experiment and another, a control experiment. In Table 5.3 above, *oshihete* added, indoor *oshikundu* and undiluted oshikundu containers were experiments. The containers of no *oshihete* added, outdoor *oshikundu* and diluted *oshikundu* were control experiments. The experiment was then left overnight until the next day, for the learners to record and discuss their observations in each group. Similarly to Maselwa and Ngcoza's (2003) Predict-Explain-Explore-Observe-Explain (PEEOE) approach, I asked learners to make some predictions first. Learners gave their predictions and explanations before the observations. For example, all groups predicted that outdoor *oshikundu* would ferment faster than an indoor one due to the higher temperature outside (see Appendix 4). However, through observation, the prediction was proven incorrect as the balloon inside the room increased in size more than the one outside, because the balloon was insulated as shown below.

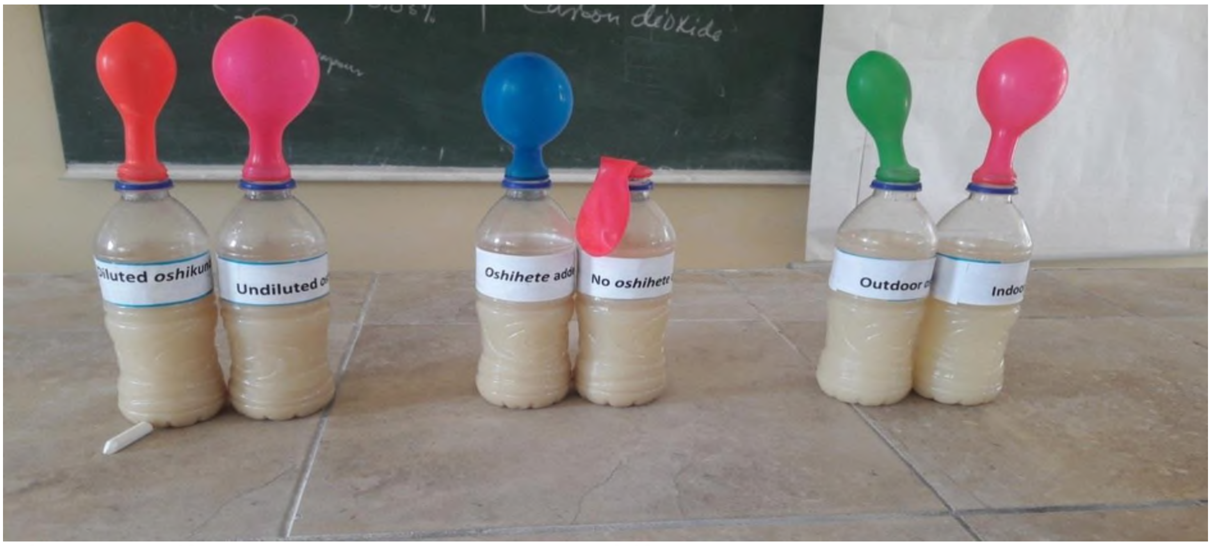

Figure 5.5: The results of the experiment the following morning

Under observation results, one group wrote: The bottle with *oshihete* added "*formed more bubbles and the balloon became bigger*". Whereas, for *no oshihete* the bottle *"formed less bubbles and the balloon is small".* This hands-on learning experience made teaching and learning of science concepts effective (Hodson, 1990; Maselwa & Ngcoza, 2003; Millar, 2010). By looking at how big the balloons were inflated, learners were able to deduce that more carbon dioxide was collected in an insulated bottle. The indoor bottle was insulated because it was kept inside the classroom with the presence of a catalyst (*oshihete*). Furthermore, another group wrote: "*Oshihete produces carbon dioxide which increases the size of the balloon and it works as a catalyst. As more oshihete is added the rate of reaction is increased"* (see Appendix 4). Another group wrote as follows; "*When oshikundu contains a catalyst and is exposed to a higher temperature, it will speed up the reaction in a short period of time, while the one without a catalyst has a slow rate of reaction"* (see Appendix 4).

In this experiment, all the conditions set for fermentation were present. Learners were asked to take note of the results of the changes they observed, as well as give possible scientific clarifications on the causes. An analysis of the responses showed that, in all five groups, the addition of *oshihete* to the mixture had increased the fermentation process.

For the Grade 11 Physical Science learners, the *oshikundu* experiment was relevant to the topic of rates of reactions (Gott & Duggan, 1996). According to the general objectives of the Grade 11 Physical Science syllabus, learners are expected to know the concept of rates of reactions. Specifically, learners should be able to define a catalyst as a substance, which accelerates or retards the rate of a chemical reaction (Earl & Wilford, 1995). The catalyst takes part in the reaction, but is chemically unchanged at the end of it, although it may change physically. Hence, I used the making of *oshikundu* to explain the working of a catalyst. In the making of *oshikundu*, for it to ferment faster, one has to add *oshikundu* residue from already fermented oshikundu called *oshihete* in my language, which is a catalyst. If one does not add *oshihete* to the *oshikundu*, it will take a very long time to ferment. It may take several hours and in our culture, *oshikundu* is needed on a daily basis. However, if one puts in *oshihete*, it takes less time. This shows that *oshihete* acts as a catalyst and speeds up the rate of the fermentation process. Herein lies Vygotsky's (1978) socio-cultural theory, that construction of knowledge depends on the interdependence of social and individual processes which occur in a cultural context. Snively and Corsiglia (2001) also add that science is embedded in our culture and hence, should be incorporated in our classroom practices.

Again, something very interesting was observed when we made *oshikundu* – even though we made it late in the afternoon, it had not fermented very well by the following morning. When I asked learners to explain this, most of them mentioned that, "*it is because of the winter season because it is very cold*". We thus also used this observation to explain how temperature affects the rate of a chemical reaction. In this regard, learners came up with many indigenous practices – for example, during winter they usually dig a hole into which they can put the clay pot of *oshikundu* for insulation purposes, or place some materials such as an old blanket around the container for insulation. During summer, they usually do not make the *oshikundu* in the evenings because it would ferment too fast and it would be over fermented the next morning due to the higher temperature. Learners also indicated that during summer, they would add just a little bit of *oshihete*, or even just wash the clay container which is used daily with *oshihete*, so that the *oshikundu* does not ferment too fast.

This example of a practical activity of making *oshikundu*, shows how one can link it to a rate of a reaction, where the speed at which reactants are converted into products, depends on the concentration, surface area, temperature and addition of a catalyst. I would therefore concur with Woodley's (2009) study that suggests that teachers involve learners more, in designing and carrying out practical experiments (hands-on) and observations (brains-on). The study maintains that good practical activities help learners understand and make sense of science concepts – for example, if you were looking at how much carbon dioxide is produced when magnesium carbonate and hydrochloric acid react, you would vary the concentration of the acid, surface area, temperature and presence of a catalyst, for an in-depth understanding.

Apart from observation of the practical activity, learners were interviewed on whether practical activities are necessary in Physical Science (see Appendix 5). This is what three learners had to say. L8 (interview) explained: "*Yes because if a learner does practical in Physical Science even in exam, she/he not going to suffer, she/he can just think of a practical that they have done. And it helps learners to understand the topic what is all about*". L7 (interview) stated that: "*Yes, it's needed to teach learners how things are made and how instruments are used practically. Learners need to do practical activities to get knowledge about things are made*". L16 (interview) thought that, "*because learners are going to learn a lot rather than when they are reading. Leaners will compare if what is written in the books is correct or wrong*".

When asked how they found the way of learning through the practical activity of making *oshikundu*, one learner stated: "*Yes, because I easily recall what was present during the practical of making oshikundu*" (Interview, L16). This is similar to the research study by Millar (2010) who believes that a practical activity is effective when learners can do what they were meant to do with objects and materials and be able to recall what they did with those objects or materials. Moreover, results showed that the responses addressing learners' scientific ideas expressed in their thinking, related to the focus of the lesson. To that end, learning experiences were modified or added, to ensure learners developed the necessary science content knowledge.

The way learners perceive and interact with one another is a very crucial aspect of instruction. Therefore, a lot of time was devoted to arranging appropriate interactions between learners and materials and interaction with one another. In a learning classroom, Vygotsky (1978) highlights that meaningful learning occurs when there is social interaction between learners. These were observed in learners working on the practical activity through discussion. In addition, social interaction also occurs between learners and those with more experience. To this notion, results from interviews with learners indicated that community members should be involved in the teaching of school science, because their knowledge is relevant to classroom science.

In answer to the question of whether community members should be involved, one learner stated that: "*Yes, because some people are good in doing some of practical activities like oshikundu. They are the ones who teach learners some ideas which a teacher cannot do*" (Interview, L7). This is an indication that collaborative learning is the key to effective learning of science. In support of this argument, Leach and Scott (2003) portray learning as originating where there is social interaction between individuals. It is therefore against this backdrop, that learners in this study carried out the practical activity together in groups.

According to Vygotsky's (1978) notion of learning in a social set-up, collaborative learning is important because it encourages cooperation and sharing of insights amongst learners in the practice of a social atmosphere. When learning is planned in this way, learners come together and start discussing a problem in order to either solve a problem, perform a certain task or achieve a common objective. In order for the participants to achieve the objectives, learners worked together in groups, exchanging ideas and assisting each other (see Appendix 3). Group members also helped each other to integrate new knowledge with existing knowledge, to question their own views and those of others. During the observation session, I used a strategy of learners working together, investigating learning, problem solving and carrying out the practical activity.

Just as there is more than one way for learning to occur, there is more than one way to stimulate and enhance participation. Data from the observation showed that active engagement and participation was determined by the teaching approaches and methods that were used, the use of learning support materials and the nature of the task to be accomplished (see Appendix 3). In this context, the practical activity stimulated and enhanced participation. Furthermore, the practical activity encouraged active and creative contributions by the learners, as well as encouraging them to make use of the knowledge and expertise that they brought to class, for example, the generating of ideas that could help solve the problem. In view of this, Maselwa and Ngcoza (2003) argue that learners participate actively when doing practical activities themselves. In this study, the practical activity (group discussion) helped learners to reflect and review their learning or apply their learning to a new setting. This was also confirmed by interview results on the necessity of practical activities in Physical Science. The results indicated that the practical activity of making *oshikundu* helped them to remember things that they had done and understand the topic better (Interview, L7 & L8).

5.2.2 Connection between classroom science and prior experiences in and out of school

Lesson observations revealed that the teaching of the theory of rates of reactions provided some opportunities for learners to build on their prior knowledge. Learners indicated that they understood every day examples of fast, slow and very fast reactions, such as burning, cooking and baking (see Appendix 3).

For the intervention of making *oshikundu*, I observed that learners were provided with an opportunity to connect their home chemistry experience to school science, as proposed by Oloruntegbe and Ikpe (2011). That suggests that they used their home experiences or knowledge to help them relate and understand classroom science – as Kuhlane (2011) concludes, science is all around us. According to her, the use of everyday examples help learners to differentiate and classify materials and their characteristics; it increases the levels of engagement of learners; the learners enjoy making links between their different experiences when curriculum is designed to facilitate such links, and it encourages learners to ask questions and hence understand the concepts better. For example, if you want to speed up the rate of the fermentation process, then you can use *oshihete* as a catalyst. During this approach, learners made multiple connections to what they already knew or to applications in real world contexts. Furthermore, they were able to apply what they learnt beyond the context of the original problem, connecting the science ideas to everyday life, as well as connecting their cultural science to modern science.

In support of this notion, Kibirige and Van Rooyen (2006) argue that ignoring indigenous knowledge in science curricula ensures that learners will experience conflict between their every day prior knowledge and curriculum science; this will therefore make it difficult for learners to cross-over from their indigenous knowledge to curriculum science. As advocated by Aikenheid and Jegede (1999), there should be a relationship between school science and what happens in children's homes, for border crossing to be successful. In other words, it will make it difficult for learning to occur when classroom approaches are irrelevant to their everyday experiences.

Kasanda et al. (2005) echoed similar sentiments by arguing that learners learn more effectively when they already know something about a content area and when concepts in that area mean something to them and to their particular background or culture. When teachers link new information to the students' prior everyday knowledge, they activate the students' interest and infuse science concepts that incorporate issues from society.

As highlighted by the research study by Oloruntegbe and Ikpe (2011), Rennie (2011) and Stears et al. (2003), these connections between prior knowledge and school science has promoted more engagement and participation by learners with each other and the content. In this study, this also made the lessons more interesting since I used what learners already knew or had experienced from home. Furthermore, it also resulted in active participation and understanding due to contextualisation of classroom science concepts, through the incorporation of indigenous knowledge. In addition, the intervention encouraged learners to respect their culture and ways of doing things (indigenous practices). For example, during the observation of the practical activity of making *oshikundu*, learners indicated that the practice is important for them to see the chemical reaction taking place in a traditional drink, the traditional way [traditional chemistry]. Moreover, it also increased their confidence and morale in the classroom.

Of course, this is contrary to Shizha's (2007) research findings on Zimbabwean teachers, who believe that indigenous knowledge has no place in the teaching of science. This finding is supported by one learner who indicates that there are no scientific concepts associated with the making of *oshikundu* (Interview, L4). However, as posited by Le Grange (2007), the main idea is to integrate Western and indigenous knowledge systems to invite active participation and engagement for effective learning to take place in the classroom.

In their contribution for inclusion of indigenous knowledge in the science curriculum, Mukwambo et al. (2014) discovered that learning is dependent on the learners making connections between prior knowledge and the content of instruction. The inclusion of the indigenous practice of making *oshikundu* illustrates the importance of the concept of Africanisation of the school science curriculum. These authors outlined that, "Africanisation has to do with methods and approaches in teaching and learning that can be adapted and made relevant to the African context" (Mukwambo et al., 2014, p. 2).

Interview results revealed that community members should be involved in the teaching of school science, because their knowledge is relevant to school science. One learner responded that: *"Yes, community members should be introduced because what is being taught in school science is practical things that people normally do at their houses for their everyday life"* (Interview, L16).

Therefore, it is evident that the inclusion of indigenous knowledge and practices of making *oshikundu* into Physical Science teaching enhances learners' engagement, participation and making sense of concepts related to rates of reactions.

During observation of the practical activity, learners revealed their underlying thinking and reasoning and the source of their preconceptions. In addition, they also recognised the links between their preconceptions or previously learned science concepts and the activities or experiences in the science lessons. For example, learners' who were asked whether Physical Science teachers should always consider learners' prior everyday knowledge or experiences when teaching Physical Science, stated the following: *"Yes because Physical Science is just general and sometimes it needs what you know or learn from home – so Physical Science they need our prior everyday knowledge*" (Interview, L8). "*Yes, because some learners do not have that experience but some have, teachers need to consider that experience to be admitted by all* *learners"* (Interview, L7). *"Yes, because most of the knowledge learners have from home is somehow related to what they are taught in Physical Science and learners are just adding to what we know from home"* (Interview, L16).

All learners pointed out that Physical Science teachers should always consider learners' prior everyday knowledge or experiences when teaching Physical Science.

5.2.3 Sense-making of intended scientific ideas and concepts

The main goal of this research study was to explore learners' sense-making of the concept of rates of reactions, through the inclusion of the indigenous practice of making *oshikundu*. In addition, the study aimed to integrate the learners' everyday practices into practical activities. Hence, the intervention was conducted with the focus mainly on enhancing conceptual understanding of the fermentation process. The cultural practice of making *oshikundu* thus served as a learning context in this practical activity.

Hodson (1990) views the purpose of practical activities as a means to motivate by stimulating interest, curiosity, excitement and enjoyment, if learners are allowed to pursue their own practical investigations in their own way. To this end, the learners that I interviewed revealed that practical activities through hands-on activities enabled them to learn concretely rather than abstractly (Interview, L8). Through the handling of materials, it is believed that the knowledge they get will remain in their long-term memories. These findings resonate with what Gott and Duggan (1996), Maselwa and Ngcoza (2003) and Millar (2004) found in their studies of the role of practical activities in the teaching and learning process.

Moreover, the findings of this study show that practical activity can have a greater potential for meaningful leaning if it is carefully designed to focus on the key scientific concepts to be developed and how these concepts are linked. This is congruent with Maselwa and Ngcoza's (2003) findings. Eliciting learners' prior everyday knowledge and experiences in conjunction with practical activities as done in this study, facilitated learners' understanding and they were then able to generate their own summaries in a form they could easily understand.

Results from the pre-test revealed that learners' scientific ways of reasoning showed a lack of sense-making of science concepts. This was confirmed by the pre-test that was aimed at testing their prior-knowledge on concepts related to rates of reactions. The results showed that these learners found it difficult to construct correct scientific explanations to respond to the questions (see Appendix 2). The results revealed that learners could not make sense of their responses to questions. Even though they selected the correct answers, they still could not explain or give correct explanations for their choices. However, lesson observations showed that the use of computer diagrams helped learners to make sense of rates of reactions concepts. This was confirmed by learners' reflections when starting and concluding each lesson (see Appendix 3).

However, learners made sense of questions that contained a few words in *oshiwambo*. For example, in the making of *oshikundu,* the question of why one has to add residue from already fermented *oshikundu* called *oshihete* or *oshipithitho* to the mixture, was well answered compared to others. The lesson observations also confirmed that some learners were not confident enough to express themselves in the English language. One learner asked her question in vernacular (*oshiwambo*): "*Hano concentration moshiwambo oshike lela*?" (What does concentration mean in *oshiwambo* language?) Kocakulah et al. (2005), whose research found that learners have more potential to understand science concepts by using their mother tongue, support this practice. Hence, language is crucial in mediating the meanings (sense-making) of the concepts. According to Vygotsky's (1978) socio-cultural theory, human activities occur in a cultural context and are mediated by language. It was therefore for this reason, that learners were given an opportunity to express themselves in the language they were comfortable with, during the teaching and learning process.

From observation of the practical activity, learners clarified their own ideas, observed, reasoned and explained science concepts. Similar to Weick et al. (2005), I observed that learners were able to self-monitor the accuracy of their understanding and revise their ideas based on scientific reasoning and evidence. For example, they came to the conclusion as to why water for making *oshikundu* should not reach boiling point and why *oshihete* needed to be added to *oshikundu*. They found that the higher temperature denatures enzymes in *oshikundu* which can stop the fermentation process (reaction) (see Appendix 4), whereas *oshihete* acts as a catalyst and speeds up the fermentation process (rate of reaction) (see Appendix 4). In addition, interview results also confirmed that there are some scientific concepts that are associated with the making of *oshikundu*. For example, one learner stated that: "*Temperature can affect the rate of reaction. Warm water can increase the rate of reaction. The concentration of oshikundu in the container affects the rate of reaction"* (Interview, L7). Another learner discovered that: *"in oshikundu there can come some gas like carbon dioxide and others"* (Interview, L16).

The intervention revealed that science content was connected to the classroom activities. Learners carried out practical experiments in small groups. As a result, as Zhang (2008) observes, more classroom talk was noticed. Furthermore, this contributed to some learners having opportunities to participate more fully through asking questions and being involved in active learning tasks and sharing information in groups. These findings are similar to those of Ash (2004). The study advocates the view that physical activities (doing) and dialogic processes (talking) lead to increased learner understanding. In their groups, learners generated and explored questions about the science in the lesson. In fact, learners articulated the intended science content of the lessons, activities, or experiences.

Moreover, many positive findings were observed during the intervention. For example, learners participated well during the practical activity. There was meaningful and effective interaction between learners, which helped learners to feel motivated and answer questions assigned to them. The practical activity also showed respectful and collegial interactions between the learners and a community woman and amongst the learners during the group discussion. This encouraged learners to be active and talk with one another. As advocated by Vygotsky's (1978) socio-cultural theory, which is the theoretical framework for this study, meaningful learning occurs when there is social interaction between learners and those with more experience. This way of knowing and talking, is also what constitutes learners' scientific practice, as echoed by Warren et al. (2001). In agreement with this notion, Ash (2004) also supports that scientific sense-making is created dialogically – in this case, that learning occurred through group discussions.

In addition, as Warren et al. (2001) state, learners make sense of science concepts in their own language and it was for this reason that most of learners' discussions were carried out in an informal language (*oshiwambo)* to encourage meaning-making. In the Namibian context, this has become a challenge that most science teachers face when using English as a medium of instruction. Therefore, as maintained by Probyn (2009), some teachers find it necessary to use learners' mother tongue and code switch in order to enhance learning (see Appendix 3).

Furthermore, the intervention (content and instruction) was adjusted, based on the background knowledge of each learner and skills of each learner. Learners used informal language (*oshiwambo*) in order to clarify things that they did not understand during the lesson. Hence, this resulted in explanations and clarifications being clear and accurate. I observed that both spoken and unspoken messages, communicated that each learner was capable of learning science. Moreover, learners' everyday experiences (ideas) and ways of talking and knowing, were expressed during the intervention session.

5.3 Concluding remarks

This chapter provided the presentation, analysis and discussion using literature reviewed in Chapter Two. The findings of the study revealed that learners understood significantly better the concept of rates of reactions, through the inclusion of the indigenous practice of making *oshikundu*. It is evident that the inclusion of indigenous knowledge and practices of making *oshikundu* into Physical Science teaching, enhances learners' engagement, participation and making sense of the concept of rates of reactions.

In the next chapter, I present the summary of findings, recommendations and conclusion.

CHAPTER SIX

SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSION

6.1 Introduction

In the previous chapters (Chapter Four and Five), I presented, analysed and discussed the findings of the data generated from the test (pre-test and post-test), observation of lessons, observation of an intervention of making *oshikundu* and interviews with learners. In this chapter, I present the summary of the research findings, recommendations and areas for future research. The study sought to answer the following research sub-questions:

1. What prior knowledge do Grade 11 Physical Science learners have of the concepts related to rates of reactions?
2. How do Grade 11 Physical Science learners make sense of rates of reactions during lessons?
3. How does a practical activity of making *oshikundu* enable or constrain:
   (a) learner engagement?
   (b) making sense of the concept of rates of reactions?

These three research sub-questions helped to answer my main research question:

How do Grade 11 Physical Science learners make sense of the concept of rates of reactions through the inclusion of the indigenous practice of making *oshikundu*?

I also discuss my personal experiences throughout this study and end with some conclusions.

6.2 Summary of findings

The data were gathered and analysed in order to answer my three research sub-questions. Therefore, a summary of the findings is presented in relation to these research sub-questions.

6.2.1 Research sub-question 1

What prior knowledge do Grade 11 Physical Science learners have of the concepts related to rates of reactions?

As alluded to earlier in Section 4.2, a pre-test was administered before an intervention in the form of a practical activity on making *oshikundu* to Grade 11 Physical Science learners. The aim was to establish the prior knowledge that the learners had on the concept of rates of reactions. The results show that learners performed poorly in the pre-test compared to the post-test. Despite the poor performance in the pre-test however, these learners at least showed some prior knowledge (Kuhlane, 2011; Oloruntegbe & Ikpe, 2011) on concepts related to rates of reactions, such as processes like fermentation and corrosion that they encountered in their everyday life situations.

This is confirmed by the pre-test scores that they obtained in the definition of rates of reactions; graphs and calculations; theories; nature of substance; activation energy; temperature; surface area; concentration; and the work of a catalyst.

6.2.2 Research sub-question 2

How do Grade 11 Physical Science learners make sense of rates of reactions during lessons?

After the pre-test was administered, learners were observed in a series of three lessons about the theory of rates of reactions. The aim was to explore how learners make sense of rates of reactions during lessons. As envisaged by Vygotsky's (1978) study, the results show that group work activities promoted learner interaction and engagement with one another and the teacher. In addition, it was through language that learners were able to make sense of the learning processes (Gibbons, 2003). Furthermore, learners were able to reflect and construct their own knowledge.

Moreover, the study indicated that learners develop less motivation to learn science in terms of interest, enjoyment and the ability to connect their everyday experiences with classroom science, when taught using the traditional method, compared to when they were taught using the practical activity of making *oshikundu*. This result agrees with Erinosho (2013) whose study indicated that learners find the learning of science abstract when teaching is completely out of touch or irrelevant with learners' reality.

During lesson observations for example, one learner asked: "*What does concentration really mean in oshiwambo language*". The learner understood the meaning of concentration when it was explained to her with reference to everyday cultural examples. This is an indication that, engagement of everyday experiences with school science, can help learners to construct knowledge. Thus, science is embedded in our culture (Snively & Corsiglia, 2001).

In addition, as highlighted by Leach and Scott's (2003) study on individual and socio-cultural views on learning in science, this study found that learners constructed knowledge when they were provided with opportunities to discuss and share ideas in groups. As envisaged by the socio-cultural theory, meaningful leaning occurred due to social interactions between learners and the teacher.

6.2.3 Research sub-question 3

How does the practical activity of making *oshikundu* enable or constrain:
(a) learner engagement?
(b) sense-making of the concept of rates of reactions?

This study revealed that the intervention where learners were given an opportunity to engage in an indigenous practice of making *oshikundu*, was highly productive. Through this practice, learners' experiences created a clear direction to determine the starting point for the teaching and learning process (Roschelle, 1995). The study postulates that learning starts firstly from prior knowledge, and only later from the presented material.

As pointed out in this study, practical activities can make lessons more interesting if the teacher uses what learners know or experience from home. Furthermore, the connection between prior knowledge and school science, promotes more engagement and participation. This will also result in understanding due to contextualisation of classroom science concepts, through integration with indigenous knowledge (Stears et al., 2003; Oloruntegbe & Ikpe, 2011; Rennie, 2011). For instance, by neglecting prior knowledge or the indigenous knowledge of making *oshikundu,* it would be hard for rural learners to understand the scientific concept of rates of reactions learned in the classroom. Thus, the exploration of a local and cultural practice of making *oshikundu* forms a foundation for learning new scientific concepts. This resonates with the explanations given in Section 5.2.2.

The findings also agree with Ogunniyi and Ogawa's (2008) study that IK has similarities with desirable classroom practices. During the intervention of making *oshikundu*, learners were able to link their everyday knowledge to school science, for example, *oshihete* acts as a catalyst during fermentation of *oshikundu.*

The study further revealed that exploring the cultural practice of making *oshikundu* could enhance sense-making in learning science. The scientific concept, rates of reactions, was presented to learners through the inclusion of an indigenous practice of making *oshikundu*. As propounded by Vygotsky's (1978) socio-cultural theory, it was noticed that more learner engagement and interactions were observed during the making of o*shikundu*.

This result also collaborates with Aikenhead and Jegede's (1999) notion of the importance of cross-cultural science education in order to help learners move between their everyday world and the world of school science. In the context of this study, learners experienced a shift between their everyday knowledge and school science [cultural border crossing] because the practical activity of making *oshikundu* helped them to cross smoothly between cultural science and school science.

After analysis of data gathered in this study, I came to the conclusion that *oshikundu* is one of the best cultural practices to contextualise science learning. It can be used when teaching rates of reactions as a food preserving process and also as a process of brewing. *Oshikundu* can also be used when teaching factors that affect the rate of a reaction. This cultural practice uses easily accessible resources, thus, it can be very useful in areas where there is lack of learning and teaching resources (Asheela et al., 2015).

6.3 Recommendations

Teaching of Physical Science generally needs to be rooted in indigenous knowledge and practices where possible. According to Snively and Corsiglia (2001), indigenous means being grown or produced in locality. Indigenous knowledge which can also mean traditional knowledge, refers to various ways of societal processes of perceiving, thinking, acting and understanding, as a result of human experience with the natural world.

Based on the findings of this study, I recommend that relevant indigenous knowledge and practices should be incorporated into Physical Science lessons especially during practical activities. Furthermore, teachers need to do more research about indigenous knowledge and document it (Kibirige & Van Rooyen, 2006). Research and documentation are necessary in order to help teachers understand what indigenous knowledge is, its importance and practical implications, including challenges, for its inclusion in the science curriculum. Likewise, science teachers should be clear about the scientific knowledge they would like enhanced through the inclusion of IK.

As acknowledged by Kibirige and van Rooyen's (2006) study, I experienced some cultural beliefs amongst many learners. For them, it is a cultural belief that some women do not have 'good hands' when making *oshikundu*. They said that if such women make *oshikundu*, it always becomes bad. This is not true because scientifically it could be due to various factors such as variations in temperature. Despite the few challenges associated with indigenous knowledge, research studies confirm the benefits for its inclusion in the science curriculum. Pertaining to this, as Mukwambo et al. (2014) suggest, I would recommend that teachers should not avoid such beliefs in the sense-making of science, but instead engage with learners about these beliefs.

Pertaining to this study, one of the challenges faced was that the learners found my teaching approach very different from that of any other science teacher. It would seem therefore that further research is also required to find appropriate ways to enable science teachers and curriculum designers to successfully incorporate indigenous knowledge in science learning repertoires. As mentioned earlier in this thesis, Kasanda et al. (2005) believe that learners learn more effectively when they already know something about a content area and when concepts in that area mean something to them and to their particular background or culture. Thus, I recommend that examinations in Physical Science, which are based on modern academic modes of learning, should include indigenous knowledge and practices that are scientifically orientated in relevant communities.

Community members should also be encouraged and invited to come to school for the making of *oshikundu*, in order to make sense of the demands of the Namibian curriculum that indigenous knowledge be incorporated in science classrooms. This is similar to the projects that integrate indigenous knowledge with modern science in schools (Erinosho, 2013; Klein, 2011; O'Donoghue et al., 2007).

Oshikundu is a homemade non-alcoholic traditional drink containing a lot of energy. Hence, *oshikundu* can be made as a change project in most Namibian schools in order to supplement the school feeding program. In most schools, learners are fed with soft porridge during break times every day. Since schools have a high number of orphans and vulnerable children including those living with HIV-AIDS, *oshikundu* consumption, when supplemented by more nutritional food, will eradicate hunger at schools. In fact, this will improve the health of learners and participation in classroom activities. As a matter of cultural heritage as well as for environmental and sustainability factors (Cocks et al., 2012), people should also be encouraged to sell *oshikundu* in their communities to discourage people from drinking *epwaka* and *otombo* which are dangerous traditional alcoholic beverages.

In conclusion, it is my belief that learners need to be encouraged in order to respect all the traditional knowledge of their ancestors, before it is lost to the modern generation.

6.4 Areas for future research

I would recommend that further research could be done on the same topic this study addressed, perhaps adopting a quasi-experimental research design, where one class is taught using the practical activity of making *oshikundu* and another without. This might help to clearly compare the mean achievement scores of learners taught Physical Science with the inclusion of the indigenous practice of *oshikundu* and those without.

6.5 Limitations of the study

The study was limited to one Grade 11 class of St. IK Secondary School (pseudonym), hence the research findings cannot be generalised. However, some knowledge and insights on how Grade 11 Physical Science learners make sense of the concept of rates of reactions through the inclusion of indigenous practice of making *oshikundu,* were obtained from this study.

6.6 Reflections

I started this research journey in 2013 when I was registered as a post-graduate student with Rhodes University for the degree of Bachelor of Education with Honours. Things were not easy at the beginning until 2015, when I was introduced to the *Ubuntu* philosophy by my Science Education lecturer, Professor Ngcoza. According to Mukwambo et al. (2014) and Le Grange (2012), *Ubuntu* philosophy is characterised by people helping one another in their society. In addition to *Ubuntu* philosophy, he told us (MEd Science group) of an old African proverb that says: "*If you want to go fast, walk alone, but if you want to go far, walk together*". This proverb motivated us to work together in order to achieve a common goal. We even created a social group where we shared information, and assisted and updated one another on our research projects.

Throughout the process, many things occurred. In early August 2015, I had a serious medical condition which really affected my morale and confidence in working on my research proposal. I can remember working on my research proposal and portfolio while being in Windhoek Central Hospital. Despite all these pressures, I still managed to make it because of the encouragement that I received from people around me. This helped me regain my momentum.

Although my condition was serious, this did not prevent me from attending the two-week research design course in Grahamstown. The main purpose of the course was to prepare us as students with the knowledge on how to go about doing research. Thus, one of the key questions was how to approach the construction of the research topic and, the relationship between the research problem and topic. This was not a difficult task for me, as I learned how to formulate a research goal and questions with Prof Ngcoza during our first session in January 2015.

Upon our arrival, the MEd Science group was welcomed by Professor Ngcoza who together with a community local expert woman, introduced us to the *isiXhosa* cultural practice of preparing and making of *umqombothi*. *Umqombothi* is made by mixing sorghum and maize malt with hot water. It is a traditional drink that is normally prepared during cultural events, for people to enjoy the celebrations. In this context, the main reason for the making of *umqombothi* was to find the science concepts that may emerge from such a practice and how it relates to everyday school science. Unlike *oshikundu*, *umqombothi* is an alcoholic beverage.

In the meantime, the traditional practice of making *oshikundu* aroused my interest – I wanted to do more research on this topic, particularly on conditions necessary for fermentation to take place. These are factors that affect the rate of reaction. In both traditional practices, we investigated how temperature, catalysts, surface area and concentration influenced the speed of a reaction. Furthermore, this was also a means of using easily accessible resources to explain science concepts to help learners understand.

To this end, this practice became my area of research – to explore how Grade 11 Physical Science learners make sense of the concept of rates of reactions, thorough the inclusion of the indigenous practice of making *oshikundu*. I am of the opinion that this study can be used as a reference point to help teachers explore how indigenous knowledge and practices through the practical activity of making *oshikundu,* may enable learner-engagement and help them make sense of the concept of rates of reactions in Namibian schools. In particular, to also gain meaningful insights, involving developing an understanding of how the teaching and learning context through indigenous practical activities cater for the natural curiosity and eagerness of young people, to learn and to investigate and make sense of a widening world.

Today, I am a researcher in education. In October 2015, I had already presented my research project at a conference launch in Windhoek, Namibia titled 'African Association for the Study of Indigenous Knowledge Systems' (AASIKS) together with my MEd Science colleague student, Eva Asheela and other senior students such as Muzwa Mukwambo, Albertina Enghono and Zukiswa Kuhlane. I am interested in recognising indigenous knowledge as a way to help learners make sense of classroom science, thus my area of focus for this study. I further wish to publish more articles locally and internationally, so that my findings can be shared with other academic scholars.

6.7 Conclusion

In this chapter, I provided a summary of the research findings. The main findings of this study concluded that the inclusion of the indigenous practice of making *oshikundu* in Physical Science teaching enables sense making of the concept of rates of reactions. Furthermore, sense-making can be made easier through the use of practical activities during instruction. Moreover, the study concluded that the connection between prior knowledge and school science, promotes more learner-engagement and participation in the subject. Based on the findings from this study, recommendations were provided and areas for future research were also highlighted.

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APPENDICES

Appendix 1: Permission letters

Appendix 1a: Permission letter to the Director of Education

Republic of Namibia
MINISTRY OF EDUCATION

JOHN A PANDENI COMBINED SCHOOL
PO Box 27, Outapi. Tel: 065-250301. Fax: 0886516235

18 March 2016

The Director
Directorate of Education, Arts and Culture
Omusati Regional Council
Private Bag 529
Outapi

Dear Sir

Subject: Permission to conduct a Science Research Study with grade 11 learners a[redacted] Secondary School

I am Kristof Shingwilila Nikodemus, a Namibian teacher currently Head of Department for Mathematics and Science (grade 6-10) at John Alphons Pandeni Combined School. At this moment, I am registered for the second year of the 2015-2016 MEd Science programme in Education, student number, 13n7414. As part of this course, one of my responsibilities is to carry out a research requiring observations and interviews related to my research study. The purpose of the research is to explore how grade 11 learners make sense of concepts on rates of reactions through the inclusion of the indigenous practice of making *oshikundu*.

According to the Namibia Senior Secondary Certificate syllabus, the topic "rates of reactions" is offered in grade 11. Hence, I hereby request your support in granting me access and permission so that I can conduct observations and interviews with the grade 11 Physical Science teachers and learners at [redacted] Secondary School from 30 May 2016 to 03 June 2016.

As noted above, this is an educational research so it will be published beyond the Education Department at Rhodes University with regard to participants' consents. Should you have any further queries or concerns, please do not hesitate to contact me personally at nshingwilila@gmail.com or Dr. Kenneth Mlungisi Ngcoza (supervisor) at k.ngcoza@ru.ac.za.

Your consideration in this regard will be highly appreciated.

Yours Sincerely

MINISTRY OF EDUCATION
THE PRINCIPAL
JOHN ALPHONS PANDENI C.S
ANAMULENGE CIRCUIT
2016 -03- 1 8
P.O.BOX 27, OUTAPI
TEL: 065-250301
OMUSATI REGION
REPUBLIC OF NAMIBIA

KS Nikodemus (13n7414)

Appendix 1b: Permission letter from the Director of Education

REPUBLIC OF NAMIBIA

OMUSATI REGIONAL COUNCIL

DIRECTORATE OF EDUCATION, ARTS AND CULTURE

Team Work and Dedication for Quality Education

Tel: +264 65 251700
Fax: +264 65 251722

Private Bag 529
OUTAPI

Enq: Apollonia Hango

22 March 2016

Kristof Shingwilila Nikodemus
John Alphons Pandeni Combined School
Anamulenge Circuit

Subject: Permission to conduct Science Research Study.

This letter serves to notify you (**Mr. Kristof S. Nikodemus**) that permission has been granted to conduct a research at [redacted] Secondary School on rates of reactions through the inclusion of the indigenous practice of making oshikundu. Please be informed that the research to be conducted at school should by no means whatsoever disrupt teaching and learning.

We hope and trust this exercise will enhance quality education in the Region.

Yours faithfully

OMUSATI REGIONAL COUNCIL
DIRECTORATE OF EDUCATION
2016 -03- 22
OFFICE OF THE DIRECTOR
PRIVATE BAG 529, OUTAPI
REPUBLIC OF NAMIBIA

....

Mr. Laban Shapange
Director of Education Arts and Culture

Teamwork and dedication for quality education

Cc: The principal for [redacted] SS
Inspector of Education

All official correspondence must be addressed to the Chief Regional Officer.

Appendix 1c: Permission letter to the school principal

Republic of Namibia
MINISTRY OF EDUCATION

JOHN A PANDENI COMBINED SCHOOL
PO Box 27, Outapi. Tel: 065-250301. Fax: 0886516235

18 March 2016

The Principal
[redacted] Secondary School
[redacted]
Outapi

Dear Sir

Subject: Permission to conduct a Science Research Study with grade 11 learners at [redacted] Secondary School

I am Kristof Shingwilila Nikodemus, a Namibian teacher educator currently Head of Department for Mathematics and Science (grade 6-10) at John A Pandeni Combined School. At the present moment, I am registered for the second year of the 2015-2016 MEd Science programme in Education, student number, 13n7414. As part of this course, one of my responsibilities is to carry out a research requiring observations and interviews related to my research study. The purpose of the research is to explore how grade 11 learners make sense of concepts on rates of reactions through the inclusion of the indigenous practice of making *oshikundu*.

According to the Namibia Senior Secondary Certificate syllabus, the topic "rates of reactions" is offered in grade 11. Hence, I hereby request your support in granting me access and permission so that I can conduct observations and interviews with the grade 11 Physical Science teachers and learners at your school from 30 May 2016 to 03 June 2016.

As noted above, this is an educational research so it will be published beyond the Education Department at Rhodes University with regard to participants' consents. Should you have any further queries or concerns, please do not hesitate to contact me personally at nshingwilila@gmail.com or Dr. Kenneth Mlungisi Ngcoza (supervisor) at k.ngcoza@ru.ac.za.

Your consideration in this regard will be highly appreciated

Yours Sincerely

....

KS Nikodemus (13n7414)

MINISTRY OF EDUCATION
THE PRINCIPAL
ANAMULENGE CIRCUIT
2016 -03- 18
P.O. BOX 27, OUTAPI
OMUSATI REGION
REPUBLIC OF NAMIBIA

Appendix 1d: Permission letter from the school principal

REPUBLIC OF NAMIBIA
Ministry Of Education
Outapi Circuit
[redacted] Secondary School [redacted]
P.O. Box [redacted], Outapi, Namibia

Tel: [redacted] Email address: [redacted]

25 March 2016

TO: Mr. Nikodemus Kristof S.
John A. Pandeni C/S
Anamulenge Circuit

Dear Mr. Nikodemus

RE: PERMISSION TO CONDUCT THE RESEARCH WITH THE GRADE 11 LEARNERS

I [redacted], Acting Principal at [redacted] SS) hereby would like to acknowledge the receipt of your letter dated 18 March 2016 on behalf of the management and entire learners, I would like to permit your request for conducting a Science Research study with grade 11 learner at [redacted] SS from 30 May 2016 to 03 June 2016.

I would also like to ensure you that our school will be ready to provide you with assistance that you may be need in carrying out the research.

Yours sincerely

MINISTRY OF EDUCATION
THE PRINCIPAL
[redacted] S S
2016 -3- 25
065-259029
P O BOX 384
OUTAPI
REPUBLIC OF NAMIBIA

....
[redacted]
(Acting Principal)

Appendix 1e: Permission letter to community lady

Republic of Namibia

MINISTRY OF EDUCATION

JOHN A PANDENI COMBINED SCHOOL
P O Box 27, Outapi, Anamulenge Circuit, Omusati Region

Enquiries [*Omaugvelele*]: Mr. KS Nikodemus
Cell number [*Onomola yongodhi*]: 081 299 6752

13 May 2016

Dear Madam [*Kuye omusimanekwa*]

PERMISSION LETTER: MAKING *OSHIKUNDU* [*EINDILO LYO KU NINGA OSHIKUNDU*]

I, Kristof Shingwilila Nikodemus am currently a Physical Science teacher at the above mentioned school who is also a part-time student with Rhodes University, South Africa. I am hereby requesting a permission from you to be a member of my research project that I will be conducting together with some learners of [redacted] Secondary School. I am doing a science related research project which is proposed to be done with 22 grade 11 Physical Science learners from 30 May 2016 up to 03 Jun3 2016.

[*Ngame, Kristof Shingwilila Nikodemus, ondi li omulongisikola poskola ya tumbulwa pombanda. Ondi li wo omwiilongi na Rhodes University ya South Africa. Ota ndi ningi eindilo ku ngoye opo ukuthe ombinga mopolondjeka yange tandi ke yi ninga naalongwa yeli 22 yo ndondo 11 moshilongwa shuunongononi posekundosikola ya* [redacted] *Secondary School oku za momasiku 30 Mei 2016 sigo 03 Juni 2016.*]

Since we will be concentrating more on the 'making of *oshikundu*', your main role will mostly to explain this cultural practice to learners.

[*Molwashoka otatu ki ikwatelela ku nkene oshikundu hashi ningwa, ngoye oto ka fatululila ounona muule omikalo nkene oshikundu hashi ningwa.*]

I will make sure that your identity will be kept confidential. [*Ota ndi ka kwashilipaleka kutya uukwatya woye owa gamenwa.*]

Hence, I request you to indicate your choice by ticking [√] in the appropriate box below. [*Ulika epitikilo lyoye mu kamwe komuukololo mbuka.*]

Agree [*Nda pitika*] ☐

Not agree [*Ina ndi pitika*] ☐

Signature [*Eshainokaha*]: ....

Your cooperation will be highly appreciated. [*Elongelo kumwe lyoye ota li ka tambulwa ko.*]

Yours sincerely [*Ngweni*]

KS Nikodemus

MINISTRY OF EDUCATION
THE PRINCIPAL
JOHN ALPHONS PANDENI C.S
ANAMULENGE CIRCUIT
2016 -05- 13
P.O. BOX 27, OUTAPI
TEL: 065-250301
OMUSATI REGION
REPUBLIC OF NAMIBIA

Appendix 1f: Permission letter to parents

Republic of Namibia

MINISTRY OF EDUCATION

JOHN A PANDENI COMBINED SCHOOL

P O Box 27, Outapi, Anamulenge Circuit, Omusati Region

Enquiries [*Omauyelele*]: Mr. KS Nikodemus

Cell number [*Onomola yongodhi*]: 081 299 6752

25 May 2016

Omuvali/Omutekuli omusimanekwa

Oshinima: Ekuthombinga lyomunona momapekaapeko

Omulongi gwoshilongwa shuunongononi (Physical Science) posikola yaJohn A Pandeni CS ota ka ninga omapekaapeko kombinga yo "rates of reactions" opamwe nomulongi gwo Physical Science gwopo [redacted] SS omolweilongo lye lyo thaathaa.

Omapekaapeko ngaka otaga ka ningilwa posikola ya [redacted] SS pethimbo lyootundi dho Physical Science, uule woshiwike shimwe, okuza omaandaha sigo etitano lyomasiku 30 Mei 2016 sigo 03 Juni 2016.

Omulongi okwa pewa nale epitiko okuza kombelewa yomukuluntu gwoshikondo shelongo nokombelewa yomukuluntusikola. Omulongi ota indile nee epitikilo komuvali opo a pitike omulongwa nguka a ka kuthe ombinga momapekaapeko ngaka. Omauyelele taga ka monika okuza momapekaapeko ngaka itaga ka longithwa nande muuwinayi washa.

Udhitha okambapila kakwatelwa ko nde to ka tumu kosikola.

Tangi unene sho to shi ningile ndje.

Neyelo gweni

....

KS Nikodemus

MINISTRY OF EDUCATION
THE PRINCIPAL
JOHN ALPHONS PANDENI CS
ANAMULENGE CIRCUIT
2016 -05- 25
P O BOX 27, OUTAPI
OMUSATI REGION
REPUBLIC OF NAMIBIA

Appendix 1g: Consent form to parents

Edhina lyomulongwa

....

Edhina lyomuvali

....

Gandja okangombe e to shaina

Eeno, onda gandja epitiko

☐

Eshaino: ....

Aawe, inandi gandja epitiko

☐

Eshaino: ....

Etompelo kutya omolwashike ino gandja epitikilo

Appendix 2: Pre-test/Post-test

Name and surname: ________________________________ **Date:**
Grade: 11 **Marks: 85**

Rates of Reactions Test **Duration:1h30 min**

Instructions and information to learners

- Write your name and surname in the spaces at the top of this page.
- Answer **all** questions.
- For Section A, there are four possible answers **A, B**, **C** and **D**. Circle the one you consider correct and explain the answer for your choice in the spaces provided.
- Write in dark blue or black pen.
- You may use a soft pencil for any rough working, diagrams or graphs.
- For each Section, the number of marks is given in brackets [ ] at the end of each question or part question.

Section A

1. The rate of a chemical reaction can be expressed in:

(a) Energy released per mole of reactant
(b) Grams per mole of reactant
(c) Moles per litre of solution
(d) Volume of gas per minute

Explain your answer [3]

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2. In a chemical reaction, if the reactants are heated, the reaction usually happens:

(a) Faster
(b) Slower
(c) At the same rate
(d) In a smaller volume

Explain your answer [3]

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3. Some chemical reactions require a substance called a catalyst. The main purpose of a catalyst is?

(a) To warm up the reaction
(b) To speed up the reaction
(c) To create more reactants
(d) To stop the reaction

Explain your answer [3]

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4. What is formed during the fermentation of glucose?

(a) Ethanol and carbon dioxide
(b) Ethanol and oxygen
(c) Ethane and carbon dioxide
(d) Ethane and oxygen

Explain your answer [3]

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5. Which factor explains why lithium metal generally reacts faster than gold metal?

(a) Concentration.
(b) Nature of the substance.
(c) Surface area.
(d) Temperature.

Explain your answer [3]

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6. Limestone reacts with hydrochloric acid to give carbon dioxide, salt and water.

Which change will increase the rate of the reaction?

(a) Increase the concentration of the acid
(b) Increase the size of limestone chips
(c) Decrease the volume of the acid
(d) Decrease the temperature of the reactants

Explain your answer [3]

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7. As the frequency and the number of effective collisions between reacting particles increases, the rate of the reaction:

(a) Increases
(b) Decreases
(c) Remains the same
(d) Approaches zero

Explain your answer [3]

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8. In an effort to speed up a reaction between a solid and a gas, one would **not**:

(a) Add a catalyst
(b) Cool the reaction down
(c) Increase the pressure on the system
(d) Use a powdered solid instead of one big lump of the same solid

Explain your answer [3]

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9. The phrase "the minimum amount of energy required to start a chemical reaction" describes:

(a) The enthalpy
(b) The potential energy of reactants
(c) The activation energy
(d) The activated complex

Explain your answer [3]

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10. Discarded iron objects rust (corrode) faster in:

(a) the desert
(b) coastal areas
(c) a dry environment
(d) a semi-arid environment

Explain your answer [3]

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11. How are the units for a rate always expressed?

(a) Change in concentration/unit time elapsed
(b) (Change in concentration) × (unit time elapsed)
(c) Unit time elapsed/change in concentration
(d) Unit time elapsed

Explain your answer [3]

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12. If the concentration of reactants is higher, the:

(a) Reaction rate is generally higher
(b) Reaction rate is generally lower
(c) Reaction rate is not affected
(d) Rate-determining step is eliminated

Explain your answer [3]

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13. The definition of rate includes which factors?

(a) Pressure, surface area and temperature
(b) Temperature, pressure and concentration
(c) Surface area, temperature and concentration
(d) Concentration, volume and pressure

Explain your answer [3]

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14. How do rates of reactions change with time?

(a) The rates increase
(b) The rates stay the same
(c) There is no way to measure the change
(d) The rates decrease

Explain your answer [3]

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15. Changing the pressure of a gas is another way of changing the:

(a) Temperature
(b) Concentration
(c) Surface area
(d) Composition

Explain your answer [3]

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16. In the preparation of *oshikundu,* why one has to add residue from already fermented *oshikundu* called *oshihete* or *oshipithitho* to the mixture:

(a) To increase the number of reactants in the fermentation process
(b) *Oshihete* acts as an inhibitor and slows down the rate of the fermentation process
(c) *Oshihete* acts as a catalyst and speeds up the rate of the fermentation process
(d) To increase the surface area of the fermentation process

Explain your answer [3]

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17. To react, gas particles must:

(a) be in the same physical state
(b) have the same energy
(c) have different energies
(d) collide

Explain your answer [3]

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18. Using data from the table below, at what time did the reaction stop?

Time/s	0	20	40	60	80	100
Volume of gas/cm^3	0	20	34	38	40	40

(a) 20 s
(b) 40 s
(c) 80 s
(d) 100 s

Explain your answer [3]

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19. Catalysts generally affect chemical reactions by:

(a) increasing the temperature of the system
(b) increasing the surface area of the reactants
(c) providing an alternate pathways with a lower activation energy
(d) providing an alternate pathways with a higher activation energy

Explain your answer [3]

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20. Enzymes are:

(a) heterogeneous in nature
(b) consumed by the reaction
(c) zero order in a rate expression
(d) biological catalysts

Explain your answer [3]

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

[20]

Section B

Question 1

(a) Why would iron filings rust faster than an iron nail?

[2]

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....

(b) Enzymes are in mould and bacteria that spoil food. Explain using your knowledge of factors affecting the rate of reaction, why food does not spoil as fast when it is refrigerated as it would at room temperature. [2]

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....
....
....

(c) Due to decomposition reactions with oxygen or carbon dioxide in the air, meat begins to feel slimy and smell spoiled. Explain using your knowledge of rate of a chemical reaction, why meat spoils less rapidly when left unsliced. [2]

....
....
....
....

(d) Based on your knowledge of factors affecting the rate of reaction:

(i) explain why *oshikundu* does not ferment faster during winter season. [2]

....
....
....
....

(ii) why is there a danger of explosions in places such as silos and coal mines where there are large quantities of powdered, combustible materials? [2]

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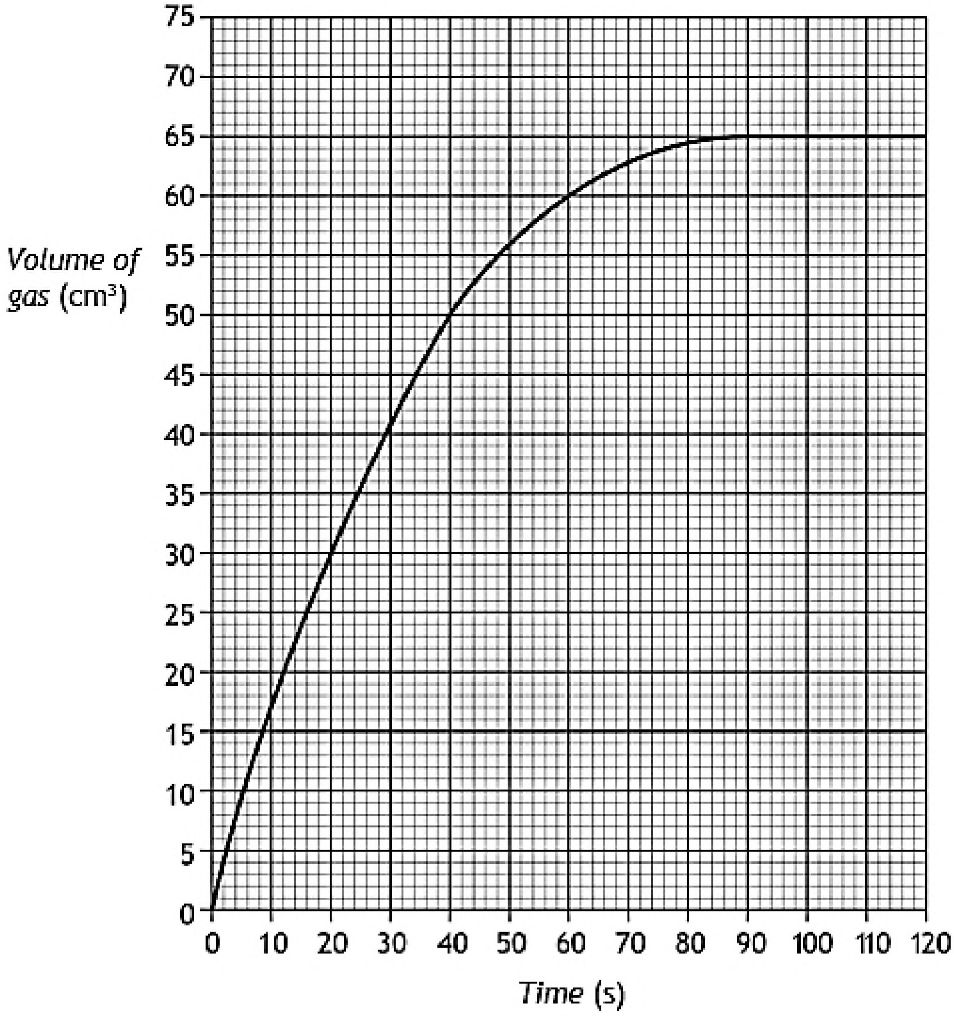
....

[10]

Question 2: Refer to the graph below to answer the following questions:



(a) State the time, in seconds, at which the reaction stopped. [1]

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(b) Calculate the average rate of reaction, in cm^3/s, for the first 20 seconds (show your working clearly). [2]

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(c) The graph shows that the rate of reaction decreases as the reaction proceeds. Suggest a reason for this. [2]

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…………………………………………………………………………………………………

[5]

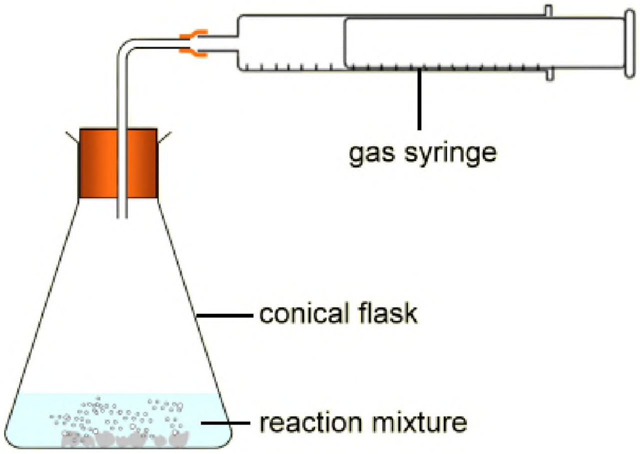
Section C

Question 1

Let's imagine we want to measure the speed (rate) of a reaction when we add 1 gram of Mg powder to 50 cm^3 of 0.5 mol/dm^3 HCl.

$$Mg + \_\_HCl \rightarrow MgCl_2 + H_2$$

The easiest way to measure the rate of this reaction is to measure the volume of hydrogen gas produced using a gas syringe.

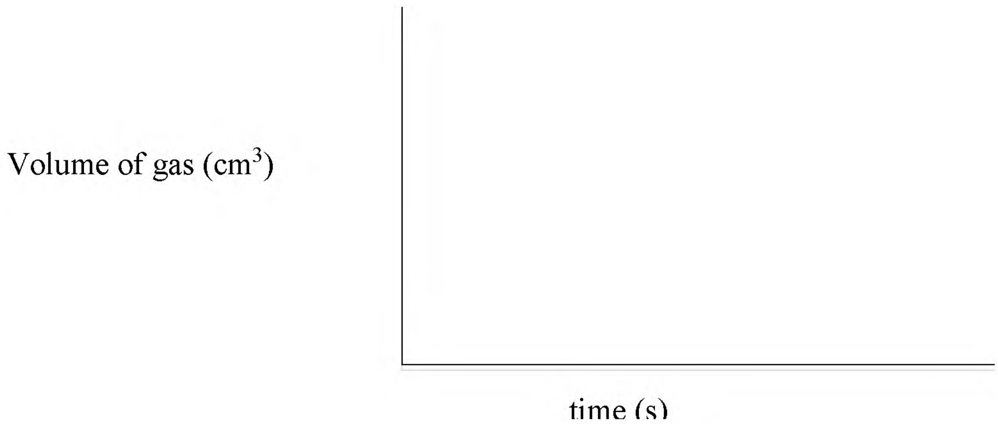


a). Balance the equation for the reaction between magnesium and hydrochloric acid in the spaces above. [1]

b). Write a word equation for the reaction. [1]

....
....
....

c). Can you sketch what you think the graph would look like if we add 1 gram of Mg powder to 50 cm^3 of 0.5 mol/dm^3 HCl at room temperature? Label this line A. [2]



d). Now, what would the graph look like if we repeated the experiment but at a higher temperature? Sketch on your graph what this would look like and label this line B. [2]

e). Which reaction was faster? Give a reason for your answer. [2]

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f). The same volume of hydrogen was produced in each experiment. What does that tell you about the mass of magnesium used? [2]

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………………………………………………………………………………………………
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[10]

Pre-test/Post-test marking scheme

Section A

Question number	Pre-test	Post-test
1	D	B
2	A	C
3	B	C
4	A	C
5	B	D
6	A	B
7	A	B
8	B	D
9	C	D
10	B	A
11	A	D
12	A	C
13	C	B
14	D	C
15	B	A
16	C	D
17	D	B
18	C	B
19	C	D
20	D	A

[60]

Section B

Question 1

(a) The rate of a reaction increases when the surface area of a solid reactant is increased.
(b) The low temperature in the refrigerator slows down decomposition reactions/a reaction goes slower when the temperature of the reactants is decreased.
(c) The reaction will go slower because the unsliced meat has a small surface area.
(d) (i) Due to a lower temperature that slow down the fermentation process.
(ii) Due to a greater surface area of the powdered materials.

[10]

Question 2

(a) 84 s [1]
(b) The average rate of the reaction = 30 cm^3/20 s
= 1.5 cm^3/s

[2]

(c) The reaction came to an end/reactants are getting used up.

[2]

[5]

Section C

Question 1

(a) $Mg + \underline{2}HCl \rightarrow MgCl_2 + H_2$ [1]
(b) Magnesium + Hydrochloric acid → Magnesium Chloride + Hydrogen [1]
(c) On the graph. [2]
(d) On the graph [2]
(e) Reaction B, at a higher temperature, the particles gain more kinetic energy and thus more successful collisions occur, increasing the rate of reaction/curve B is steeper than curve A [2]
(f) The same mass of magnesium will give the same volume of hydrogen whether the reaction is slow or fast. [2]

[10]

Appendix 3: Classroom Observation Schedule

Name of School: _______________________ Observation Date: _________________
Name of Teacher: ______________________ Grade: __________________________
Subject: _____________________________ Number of Learners: ______________
Lesson Topic: _________________________ Observer: _______________________

Organisation	Notes
Teacher and learners are well prepared for class	
Teacher records learners' attendance	
Teacher and learners use class time efficiently	
Teacher relates new topic to previous topic(s), or provides learners with opportunities to do so	
Teacher provides and follows an outline or organisation for the class lesson	
Teacher has all necessary materials and equipment readily available	
Teacher uses effective transitions between class topics	
Teacher conveys the purpose of each class activity or task	
Teacher completes the scheduled topics	
Teacher summarises periodically throughout and at end of class or prompts learners to do so	

Instructional method	Notes
Teacher uses a variety of instructional methods	
The learning materials demonstrate a logical progression with learners' prior experience and knowledge	
Teacher allows adequate wait time when asking questions	

Teacher responds to wrong answers constructively	
Teacher draws non-participating learners into activities/discussion	
Teacher prevents specific learners from dominating activities/discussion	
Teacher asks probing questions when learners' answers are incomplete	
Teacher responds to questions clearly and promptly	
Teacher guides the direction of the discussion	
Teacher refrains from answering own questions	
Teacher mediates conflict or differences of opinions	
Teacher uses active learning strategies (group work, paired discussion, polling)	
Teacher provides explicit directions for active learning tasks	
Teacher allows sufficient time to complete in-class activities	
Teacher specifies how learning tasks will be evaluated (if appropriate)	
Teacher provides opportunities for learners to practice what they have learnt	
Teacher carryout demonstrating experiments with learners	
Teacher uses teaching technique(s) appropriate to the instructional goals for this lesson	
Teacher proceeds at an effective pace	
Teacher uses positive reinforcement to encourage learners participation	
Teacher uses appropriate technology (e.g., multimedia, electronic grade book, etc.)	
Teacher provides clear directions for group work/labs/exercises	
Teacher assesses learners' learning	
Materials and equipment provide a wide range of experiences	

Decoration on walls (posters, flip charts, learners' works, etc.)	
Teacher makes material interesting to learners	
Social interaction	**Notes**
Learners participating during the lesson	
Effective learner interactions with one another	
Effective learner interactions with the teacher	
Learners' viewpoints are welcomed and respected	
Learners treated equitably	
Learners feel motivated	
Appropriate interaction between teacher and learners	
Learners' comprehension or puzzlement is attended to respectfully	
Learners are asked questions that challenge them to think more deeply	
Learners are invited to participate and give their comments	
Learners' responses are incorporated when appropriate	
Learners are encouraged to respond to their peers throughout the discussions	
Learners treat one another and the teacher with respect	
Learners are encouraged to interact civilly/respectfully with each other	

Language usage	Notes
Teacher uses appropriate and clear language	
Learners everyday experience (ideas) and ways of talking and knowing are expressed during the lesson	
Teacher and learners use informal language for meaning making processes	

Sense making	Notes
Learners every day ways of reasoning is scientific	
Learners' construct clear scientific explanations	
Learners' questioning invites thinking	
Learners arguing and presentation of information	
Learners interpretations of concepts and ideas	
Learners exploring concepts and ideas	

Learner engagement	Notes
Learners involved in active learning task	
Learners "talk and act" more than "sit and listen"	
Learners share information in groups/pairs/individually	
Learner-teacher, learner-learner, learner-material	
All learners have the opportunity to participate in questions and activities	
Specific learners' responses are elicited by the teacher	
Learners respond in an appropriate manner (no shouting out, etc.)	
Learners communicate openly and shows genuine interest in teacher	
Learners are involved in doing practical work	
Learners answer teacher's questions	
Learners talking with other learners	
Learners writing, drawing and reading	

Observer's Name: __________________ Signature: __________ Date: ___________________

Teacher's Name: ___________________ Signature: __________ Date: ___________________

Appendix 4: Worksheet experiment

Instructions:

- Follow all procedures
- Answer all the questions

Apparatus needed:

- Cooking pot
- Water
- *Mahangu* flour
- Sorghum flour
- *Oshihete (oshipithitho)*
- Plastic bucket
- Six plastic bottles (same)
- Six balloons

PROCEDURES

1. Heat water in a cooking pot up to about boiling point
2. Add hot water to a mixture of *mahangu* and sorghum flour in a plastic bucket
3. Keep on stirring the mixture until it cools down
4. Add cold water to the mixture to dilute the mixture
5. Add *oshihete (oshipithitho)* to the mixture
6. Label six plastic bottles: Pair A (*oshihete* added & no *oshihete* added), Pair B (indoor *oshikundu* & outdoor *oshikundu)*, and Pair C (Undiluted *oshikundu* & diluted *oshikundu)*
7. Add *oshikundu* to each bottle as shown by the labels above
8. Cover each mouth of the plastic bottle by tightly putting a balloon on it

WRITE DOWN YOUR PREDICTIONS FOR THE EXPERIMENT:

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NOW ANSWER THE FOLLOWING QUESTIONS:

(a) Which plastic bottle is the control in each pair of these experiments?

Pair A

……………………………………………………………………………………………

Pair B

……………………………………………………………………………………………

Pair C

……………………………………………………………………………………………

(b) What did you observe to both plastic bottles?

Oshihete added

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No *oshihete* added

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Indoor *oshikundu*

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……………………………………………………………………………………………

Outdoor *oshikundu*

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Undiluted *oshikundu*

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Diluted *oshikundu*

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(c) What conclusion can you draw from these results?

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(d) It is suggested that water used to make *oshikundu* should not reach boiling point. What do you think is the reason for this?

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(e) What do you think is the reason why some people cover *oshikundu* container with a blanket during winter?

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(f) Why was *oshihete (oshipithitho)* added to the mixture?

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(g) A catalyst is a substance which can alter the rate of a reaction without being chemically changed at the end of it. State and give a reason for a substance that acted as a catalyst in this experiment.

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(h) With reference to your knowledge on factors that affect the rates of reactions, explain how the effect of diluting *oshikundu* change the rate of the fermentation process

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(i) When making fire, people normally use small sticks rather than big size woods. Suggest a reason for this.

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Appendix 5: Individual interview schedule with learners

During this interview, the following questions will be posed to three Grade 11 Physical Science learners who are my research participants in this study. The aim is to find their views and experiences of the lessons and understanding of the learning processes.

Background

Oshikundu is a commonly respected traditional drink particularly amongst most of *oshiwambo* people in the northern part of Namibia. As a child who grew up in this community where *oshikundu* is made, you are requested to answer the following questions.

The questions are as follows:

(1) From your own experience and knowledge, explain how *oshikundu* is made (give the step-by-step procedures).

(2) What materials are needed in order to make *oshikundu*?

(3) Is it men or women who normally make *oshikundu*? Why or why not the others?

(4) Approximately, how long does it take to make *oshikundu*? Any reason?

(5) Is there any way to speed up the process of making *oshikundu*? Any comments?

(6) Is there any scientific concepts you could think of that are associated with the making of *oshikundu*?

(7) Who drinks *oshikundu*? When? Any restriction?

(8) Do you think the making of *oshikundu,* is a good practice or not at school? Why or why not?

(9) Do you think community members should be or not involved in the teaching of school science? Is their knowledge relevant?

(10) Do you think Physical Science teachers should always consider learners' prior everyday knowledge or experiences when teaching Physical Science?

(11) As a Physical Science learner, was it helpful or waste of time to explore how *oshikundu* is made culturally?

(12) Is practical work necessary in Physical Science? Give reasons.

(13) How do you see or find the way of learning through the practical activity of making *oshikundu*? Comments.

(14) How do you feel to be a member or a participant of the *oshikundu*?

Interview transcripts and initial colour coding

Me: What materials are needed in order to make *oshikundu*?
L: Water, *oshihete*, flour (*mahangu),* sorghum four, sugar.
Me: From your own experience and knowledge, explain how *oshikundu* is made (give the step by step procedures).
L: Step 1: boil water and pour it on the bucket
Step 2: add some flour both sorghum and *mahangu*
Step 3: mix them
Step 4: after cooling down add the mixture to *oshihete* that is working as a catalyst and add more water
Me: Is it men or women who normally make *oshikundu*? Why or why not the others?
L: Women, because they got an experience on it and their one who use to pound, and *oshikundu* is made at the kitchen.
Me: Approximately, how long does it take to make *oshikundu*? Any reason?
L: It only take only about 15 minutes and then you done, because maybe 10 minutes it is for boiling water and other five is to mix it.
Me: Is there any way to speed up the process of making *oshikundu*? Any comments?
L: Yes, by increasing the temperature when you are boiling water so that it cannot take long to get boil.
Me: Is there any scientific concepts you could think of that are associated with the making of *oshikundu*?
L: Yes, because in *oshikundu* there can comes some gas like carbon dioxide and others. It also contain activation energy.
Me: Who drinks *oshikundu*? When? Any restrictions?
L: Everyone drink *oshikundu* any time he/she feel like. *Oshikundu* it is not restriction to anybody because it is a kind of food.
Me: Do you think the making of *oshikundu,* is a good practice or not at school? Why or why not?
L: Making *oshikundu* is a good practice at school, because if you drink *oshikundu* you are not going to feel hungry and you are going to study very well.
Me: Do you think community members should be or not involved in the teaching of school science? Is their knowledge relevant?
L: Yes, community members should introduced because what is being taught in school science it practical things that people normally do at their houses for their everyday life.
Me: Do you think Physical Science teachers should always consider learners' prior everyday knowledge or experiences when teaching Physical Science?
L: Yes, because most of the knowledge learners have from home is somehow related to what they are taught in Physical Science and learners are just adding to what we know from home.

Me: As a Physical Science learner, was it helpful or waste of time to explore how *oshikundu* is made culturally?
L: It was helpful, because we learn a lot and we add a lot to what we were having or what we know from home.
Me: Is/are practical activity necessary in Physical Science? Give reasons.
L: Yes, because learners are going to learn a lot lather than when they are reading. Leaners will compare if what is written in the books is correct or wrong.
Me: How do you see or find the way of learning through the practical activity of making *oshikundu*? Comments
L: Yes, because I easily recall what was present during the practical of making *oshikundu*. I will follow all that was done during the practical and I directly learn how to make own *oshikundu.*
Me: How do you feel to be a member or a participant of the *oshikundu*?
L: I feel good, because I learn a lot rather than those who are not taking part. Those who are not taking part they only having the knowledge from home.