An investigation into how Grade 8 Natural Sciences learners make sense of chemical reactions during lessons involving familiar resources: A case study

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By

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DECLARATION

I, the undersigned, hereby declare that the work contained in this dissertation is my own original work and has not previously in its entirety or in part been submitted at any university for a degree.

Signature: F. Mashozhera　　　　　　　　　　　　　　　　　　　Date: 18 March 2016

ABSTRACT

My experience of working with science learners for the past 25 years and witnessing their difficulty in comprehending chemical reactions motivated me to investigate how learners make sense of chemical reactions in lessons involving the use of familiar resources. Essentially, this study sought to gain insights into whether engaging learners during practical activities using familiar resources facilitated meaning-making of chemical reactions.

There is not much literature on early high school learning of concepts linked to chemical reactions which opened the way for this research. This study was conducted at a public high school comprised of Grades 8-12 (FET band) in Grahamstown in the Eastern Cape, South Africa. It is located within the interpretive paradigm. Within this paradigm, both quantitative and qualitative methods were conducted with a Grade 8 Natural Sciences class.

Data sets were analysed in relation to the research questions. A variety of data gathering techniques were used, namely diagnostic and summative tests, worksheets and a semi-structured interview with a focus group. Both inductive and deductive processes were applied during the data analysis process. The validation process was done through data analysis using mixed methods (quantitative and qualitative), checking transcriptions with the focus group and the use of a research participant. Learners in the focus group verified their responses, checking for any misrepresentations.

The main finding of this study is that the use of practical activities, using familiar resources, facilitated learner engagement and meaningful learning. However, this study further revealed that some concepts associated with chemical reactions were challenging to learners. Similarly, that some prior everyday knowledge and experiences that learners bring to the science classroom impede sense-making in Natural Sciences. In addition, the language of learning and teaching (LoLT) and the language of science are other factors impeding sense-making of scientific concepts.

It is thus recommended that teachers plan well in order to incorporate the use of practical activities using familiar resources during mediation of learning.

DEDICATION

This thesis is dedicated to my wife, Feresiya Mashozhera and my children: Hope Kudakwashe Mashozhera, Nigel Nyasha Mashozhera and Craig Farai Mashozhera. They all care for my welfare and are very supportive of me.

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LIST OF ABBREVIATIONS AND ACRONYMS

ACE-	Advance Certificate in Education
DoE-	Department of Education
CALP-	Cognitive Academic Language Proficiency
CAPS-	Curriculum and Assessment Policy Statement
ESL-	English Second Language
FAL-	First Additional Language
HSRC-	Human Sciences Research Council
IEA-	International Association for the Evaluation of Educational Achievement
LoLT-	Language of Learning and Teaching
M.Ed-	Master of Education
OBE-	Outcomes-based Education
SRI-	Stimulated Recall Interview
STD-	Standard Teaching Diploma
RNCS-	Revised National Curriculum Statement
ZPD-	Zone of Proximal Development

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CHAPTER 1: SITUATING THE STUDY

1.1 Introduction

The main goal of the study was to investigate how Grade 8 Natural Sciences learners make sense of chemical reactions during lessons involving the use of familiar resources. In this chapter, the background and rationale of the study are described. This is followed by the curricula issues based on transformation from Outcomes-based Education (OBE) to Curriculum and Assessment Policy Statement (CAPS). A summary of the research goal and questions is presented. The theoretical framework and the potential value of the study are highlighted and definitions of key concepts are provided. Lastly, an outline of the thesis is discussed.

1.2 Background to the study

1.2.1 The International and Regional context

The study was prompted by the generally poor performance of Natural Sciences learners in South Africa in a series of international benchmark tests referred to as the Trends in International Mathematics and Science Study (TIMSS). The TIMSS 1998/1999 study revealed comparatively poor performances by the South African Grade 8 Natural Sciences learners (Howie, 2001). The TIMSS was developed by the International Association for the Evaluation of Educational Achievement (IEA) and is managed locally by the Human Sciences Research Council (HSRC) on behalf of the Department of Basic Education (DBE). The TIMSS 2011 report states that at Grade 8 level, South African learners' scores were among the bottom six of 42 countries and below the low-performance benchmark. According to the TIMSS 2011 highlights, the lowest performing provinces were Kwazulu-Natal, Limpopo and Eastern Cape. This provides good reason to locate this study in the Eastern Cape which is one of the worst performing provinces.

Question-by-question analyses of the national Grade 9 Natural Sciences common examinations at provincial level have been carried out up to 2009 (Xipu, 2011). The results revealed that learners performed poorly on questions in the Matter and Materials knowledge strand of Natural Sciences This is the strand in which chemical reactions (the focus of this study) is located. According to Xipu (2011), learners struggled with both multiple choice questions and structured questions. They could not easily name and state formulae for chemical compounds. In addition, writing and balancing the chemical equations was a further complication. Xipu (2011) conducted a study on how Natural Sciences teachers mediate learning of chemical reactions in Grade 9, in a school in the Eastern Cape Province of South Africa. The study found that learners resorted to memorising concepts and had forgotten them by the time they wrote common examinations. The poor performance highlighted by Xipu (2011), could well have stemmed from learner misconceptions of the topic Matter and Materials, so it is the intention of this research to examine how they understand related topics.

Learner misconceptions were identified and discussed by teachers, including the researcher, in 2014, during a presentation on chemical reactions in the Chemistry Department at Rhodes University. The Chemistry Department hosted science students from the Education Department during a contact session. Some teachers later confessed to having had these misconceptions themselves for a number of years. These confessions lend credence to Boo's (2002) observation that "misconceptions held by a group of students who had undergone several years of chemistry instruction are often robust and resistant to change despite teaching strategies specially designed to address them" (p. 55). It follows that learners may carry misconceptions from one grade to another. Thus, misconceptions identified in early high school Natural Sciences learning need to be addressed via teacher interventions before they crystallise and become more problematic in later grades.

The researcher set learners a diagnostic test to identify their misconceptions. Thereafter an intervention was implemented to investigate how learners develop 'new' understandings or meanings in the science classroom. The strategy and value of implementing interventions to investigate how learners develop new understandings in science classroom was proposed by Scott (1998). Since the process of sense-making or meaning-making could be hindered by misconceptions that learners bring into the classroom, the study needed to consider learners' prior knowledge related to the topic Matter and Materials. The concept of meaning-making is unpacked in the conceptual framework.

In this study, the researcher drew on his experience as a science teacher having taught the subject for the past 25 years and witnessed learners' difficulty in comprehending concepts in chemistry. Rogers (2000) identifies two explanations for learners experiencing problems with chemistry concepts. The topics are very abstract and the language of chemistry is new and unfamiliar. Considering these problems, learner participants in the study carried out practical activities in groups using resources they were accustomed to. The use of practical activities using familiar resources was an attempt to make the content of chemical reactions less abstract and more accessible. Learners answered questions on worksheets after each practical task. The use of worksheets was employed for the purpose of assisting learners who were grappling with scientific language and also served as one data collection tool for identifying how learners make sense of chemical reactions.

The teaching and learning of chemical reactions has been embedded in the laboratory at high school level. In some cases, learning has been hampered by the lack of laboratories and equipment in many schools. Where laboratories are available, they often do not have enough equipment for the proper learning and teaching of science. This is the reason why the use of familiar resources was included as a central feature in this study. Familiar resources are materials learners are at ease with as they interact with them in their daily activities.

Having established the nature of the challenge the present study sought to address, it is imperative that the specific challenge be located within the broader context of science education within the South African context. This will provide a rationale for the prioritisation of the specific challenge in this study.

1.2.2 The South African context

After independence in 1994, the South African education system went through a number of reforms intending to move away from the previous apartheid system of education (Mouton, Louw & Strydom, 2012). According to Mouton et al. (2012), the adoption of OBE was a way to abolish apartheid education and, to address outcomes of skills, knowledge and values deficient in the country. The new OBE curriculum replaced textbooks with workbooks and learner portfolios. Furthermore, outcomes replaced syllabi and learner-centred pedagogy was promoted (ibid.).

According to Mouton et al. (2012), the implementation of the curriculum resulted in a plethora of problems. These included moving away from the crucial basics in education like reading, writing and arithmetic. OBE also attempted to shift from a teacher-centred to learner-centred approach. Mouton et al. (2012) observed that teachers were not receptive to the OBE curriculum as they perceived it as problematic. In addition, the OBE curriculum had already failed in some first world countries. Issues like poverty, shortages of classrooms and lack of vital amenities impacted negatively on education (ibid.). As a result, there was an urgent need to re-think OBE.

In 1999, the Minister of Education instituted a review of curriculum 2005 (C2005), as part of its OBE program. This led to the introduction of the Revised National Curriculum (RNC). The Revised National Curriculum consisted of the Revised National Curriculum Statement Grades

R-9 and the National Curriculum Statement Grades 10-12 (2002). Administrative tasks and curriculum tools were minimised. However, the serious problems of quality, equity and relevance which were facing South African education were not addressed in this system (Steyn, Steyn, De Waal & Wolhuter, 2011).

Problems persisted, and in 2010, the then Minister of Education, Angie Motshekga, announced a new curriculum improvement process. This resulted in the crafting of the National Curriculum Statements (NCS) Grades R-12 (Maluleka, 2011). This represented a policy statement for learning and teaching in South African schools, embodying the Curriculum and Assessment Policy Statement (CAPS) document. Transformation in CAPS included a reduction in subjects from 8 to 6 for Grades 4-6, the compulsory introduction of an additional language from Grade 1, extended hours to focus on languages, fewer projects and a single file for teacher planning (Maluleka, 2011). These changes were presumably meant to improve the quality of teaching and learning in schools.

With each new curriculum, subject content and methodologies shifted as did the aims. In terms of Natural Sciences, the shift was also manifested in the aims. For instance, CAPS for Grades 7-9 Natural Sciences has three specific aims. Aim 1 is “acquiring knowledge of Natural Sciences concepts, processes, phenomena, mechanisms, principles, theories, laws, models etcetera.” Aim 2 is “investigating phenomena” (DBE. CAPS, 2011, p. 9). Specific Aim 3 is the “understanding the uses of Science”. This aim explicitly states that “learners should understand the uses of Natural Sciences and indigenous knowledge in society and the environment” (ibid., p. 10). The same observation is made by Mukwambo, Ngcoza and Chikunda (2014) as well as Kibirige and Van Rooyen (2006) who purport that the National Curriculum Statement clearly states that teachers should address indigenous knowledge in the classroom.

For learners at Grade 8 level prior knowledge is assumed to be part of indigenous knowledge. The way that Chemical reactions, a topic in Natural Sciences, is taught relies on learners’ prior everyday knowledge. Many researchers including (Roschelle, 1995; Stears, Malcolm & Kowlas, 2003; Rennie, 2011) advocate integration of prior everyday knowledge in the teaching of science as an effective way to acquire knowledge through interactions in the social context.

By employing a mixed methods research approach I sought to gain some insights into how Grade 8 learners make sense of chemical reactions when using familiar resources.

1.3 Research goal and questions

1.3.1 Research goal

To investigate how Grade 8 learners make sense of chemical reactions when using familiar resources.

1.3.2 Main research question

How do Grade 8 learners make sense of chemical reactions when using familiar resources?

1.3.3 Sub-questions

- How do Grade 8 Natural Sciences learners make use of prior everyday knowledge to construct their understanding of chemical reactions?
- To what extent do practical activities involving familiar resources enhance or constrain the learning of chemical reactions in Grade 8 Natural Sciences lessons?
- Which concepts related to chemical reactions do Grade 8 Natural Sciences learners find most challenging?

1.4 Theoretical framework

The purpose of a theoretical framework is to guide and direct the research project (Mouton, 1996). It is the framework that provides a structure for organising and supporting ideas in research work (Leshen & Trafford, 2007). The theoretical framework for this study draws from Vygotsky's (1978) social constructivism and its value in this study is further unpacked in the literature review.

1.5 Data gathering techniques

To gather data, a variety of data gathering techniques were employed which include:

- Diagnostic test;
- Lesson observations;
- Summative test;
- Focus group interviews; and
- Stimulated recall interviews.

1.6 Definition of key concepts

Certain concepts appear frequently in the research study. These are chemical reactions, familiar resources, sense-making, conventional chemicals, prior everyday knowledge, social constructivism and physical change. They are defined as endorsed by authors who conducted related studies in Chapter 2 of this study as:

Chemical reactions: this is a change which forms new substances.

Familiar resources: are materials learners are familiar with as they interact with them in their daily activities.

Sense-making: the process by which people give meaning to experiences.

Conventional chemicals: these are manufactured chemicals that are used during science to help learners understand scientific concepts.

Prior everyday knowledge: the formal and informal information learners have acquired from home, which may be scientific or non-scientific.

Social constructivism: is a theory, which states that knowledge is socially and culturally constructed through human activity.

Practical activities: these are tasks were learners manipulate real materials for themselves or in small groups that leads to better learning.

Physical change: one in which there is no change in substance.

Chemical change: a change which is the result of a reaction where one or more new substances are formed.

1.7 Potential value of the study

According to Nakhleh (1992), many learners are unable to construct appropriate understanding of fundamental chemical concepts from the start of their studies. Thus, learners from middle school to college level find learning chemistry difficult (ibid.). The research assumes that using familiar resources during the mediation of learning could enhance learners' sense-making of the content in that:

- The study can inform the education community and researchers whether practical activities involving the use of familiar resources enhance or constrain the learning of chemical reactions in Grade 8 Natural Sciences lessons;
- Facilitate the building of a Natural Sciences school kit consisting of familiar resources after the intervention. This would provide possible activities and resources which may help in improving the learners' performance and lay a solid foundation for early high school Natural Sciences learning;

- A Unit of work will be developed from this study in collaboration with the research participant. This will help the Natural Sciences teachers in the cluster to enhance their conceptual understanding of learners during mediation; and
- The study may help in the understanding of the influence of such an approach to early learning of chemical reactions. This will help as there is a lack of research on early high school learning of concepts linked to chemical reactions using familiar resources in the South African context.

1.8 Thesis outline

The research was conducted at one high school in Grahamstown, Eastern Cape Province and the thesis consists of six chapters. The following is an overview of the chapters.

Chapter 1

The first chapter of the study explains the goal and structure of the study. A discussion of the background of the research is presented and the rationale of the study outlined. The research goal and questions were presented and lastly, the potential value for the study is discussed.

Chapter 2

The chapter reviews literature related to the study. Factors such as prior everyday knowledge, practical activities, language use and sense-making are discussed. The theoretical framework underpinning the research project, constructivism, particularly social constructivism, is also discussed in this chapter.

Chapter 3

The chapter looks at the research design and it justifies why mixed methods were employed to answer the research questions. The methodology and research techniques used in this study are explained. Furthermore why worksheets, semi-structured interviews, lesson presentations, stimulated recall interviews and focus group interviews were used as data collection techniques are discussed in detail. The use of convenience and purposive sampling is also debated. Lastly, data analysis, issues of ethics and validity are discussed.

Chapter 4

This chapter presents the data analysed from the worksheets, interviews and lesson presentations. The emerging concerns from presentations, learners' interviews and learners' work are presented.

Chapter 5

Chapter 5 deals with the discussion of the findings and the themes that emerged in the study. Results from Chapter 4 are discussed with reference to the theoretical framework and literature. Discussions of interviews and learners' work conclude the chapter.

Chapter 6

The chapter outlines the main findings**.** This chapter presents limitations as well as some recommendations for further study. Finally, a conclusion based on the study is presented.

1.9 Concluding remarks

This chapter presented the context of this study, research goal and questions. The research background and the potential value of the study were presented. To enable the reader to have an insight into the research the thesis outline was presented.

The next chapter discusses the literature consulted for the study and the theoretical framework that informs it.

CHAPTER TWO: LITERATURE REVIEW

2.1. Introduction

The main goal of the research study was to investigate how Grade 8 Natural Sciences learners make sense of chemical reactions during lessons involving the use of familiar resources. This was aimed at making a contribution to improved mediation of learning of chemical reactions at high school.

In this chapter, literature relevant to how learners make sense of chemical reactions is discussed. This includes the curriculum expectations of the grade and the conceptual framework of the topic. A review of related studies namely: prior everyday knowledge, language and science, practical activities, chemical reactions and meaning-making or sense-making are discussed under the idea of a conceptual framework. The theoretical framework employed in this study is social constructivism which will help to gain insight into how learners make sense of chemical reactions.

2.2. Curriculum expectations

Since the introduction of Curriculum 2005 (C2005), many questions have been raised regarding its relevance to the South African learner. Cocks, Alexander and Dold (2012) note that in a bid to market itself as globally competitive, South Africa's curriculum 2005 (C2005) primarily focused on western-based scientific knowledge, which side-lines the contribution of indigenous knowledge systems and ignores the holistic nature of indigenous world views. To this end, Cocks et al. (2012) caution that when indigenous communities lose their cultural heritage in the form of customs, values and indigenous knowledge, the youth could become lost and turn to antisocial behaviour that affects the teaching and learning process.

In order to redress the issue of indigenous knowledge, the Department of Basic Education structured the Natural Sciences curriculum in such a way that it has three learning outcomes, namely; scientific investigation, constructing science knowledge and science society and the environment. However, Cocks et al. (2012) argue that while South Africa's OBE curriculum has an environmental component and teachers are encouraged to utilise local examples to illustrate lessons, this rarely happens in practice. Although the reasons for this are numerous and complex, the major reason is that the teachers were not adequately prepared for the curriculum implementation (Mouton et al., 2012).

In response to the emergence of multicultural classrooms in many parts of the world, curriculum transformation and development has been developed to make the school experience more relevant to learners' home experiences according to Ogunniyi and Ogawa (2008), They further point out that these curricula (non-western developed and developing worlds) have been bold attempts to reflect some elements of indigenous knowledge in science classrooms. Findings from a multitude of studies have consistently shown that learners learn science better if the content of instruction is relevant to their immediate context, which is their everyday knowledge (Roschelle, 1995; Rennie, 2011). In response to that need, the Department of Education introduced CAPS to bring more structure and direction in the curriculum. The introduction was meant to close off loopholes identified in the RNCS's.

The Curriculum and Assessment Policy (CAPS, 2011) when discussing indigenous knowledge systems and Natural Sciences, confirms:

> *These sets of knowledge, each woven into the history and place of people, are known as indigenous knowledge systems. Indigenous knowledge includes knowledge about agriculture and food production, pastoral practices and animal production, forestry, plant classification, medicinal plants, management of biodiversity, food preservation, management of water and soil, iron smelting, brewing, making dwellings and understanding astronomy, As society changes, some of that knowledge is being lost.* (Department of Basic Education, 2011, p. 8)

Mukwambo, Ngcoza and Chikunda (2014) concur that the acknowledgement of indigenous knowledge systems in the CAPS document is an important move towards meaningful learning in science. However, they observe that indigenous knowledge is not a bag of knowledge waiting to be tapped into and dispensed. It has to be critically analysed before it can be used, to expose any contradictions that might come with it.

In addition, Mukwambo et al. (2014) as well as Kibirige and Van Rooyen (2006) emphasise that teachers need to make science appealing to all learners by incorporating indigenous knowledge during their lessons. This is alluded to in the CAPS document, more specifically in Aim 3 on understanding the uses of science, where it explicitly states that "learners should understand the uses of Natural Sciences and indigenous knowledge in society and the environment" (DBE. CAPS, 2011, p. 10). By the same token, Kibirige and Van Rooyen (2006) confirm that the National Curriculum Statement clearly states that indigenous knowledge should be addressed by teachers in the classroom. Supporting this, Le Grange (2007) adds that the promotion of indigenous knowledge systems has been identified as one of the principles on which the National Curriculum Statements for both General Education Training and Further Education Training Bands in the country are based.

Le Grange (2007) further attests that the inclusion of indigenous knowledge in the Curriculum Policy Statements is a positive step and could provide opportunities for debate on interactions between western and indigenous world views. Any science curriculum that does not incorporate the indigenous world views of the learner may risk destroying the lens through which the learner is likely to interpret concepts. Le Grange (2007) maintains that effective learning will depend on teachers' understanding of this interaction and their ability to manage classroom discourses related to this matter. The CAPS document has a section on indigenous knowledge in every strand throughout the curriculum. This section requires teachers to instruct learners on the indigenous ways of knowledge.

In the study of chemical reactions, teachers are required in CAPS to teach learners chemical reactions in the fermentation process in the brewing of traditional beer. The teacher is required to draw upon learners' prior everyday knowledge in the topic of chemical reactions. In this study, practical lessons were presented using resources they are accustomed to as well as using conventional chemicals from the science laboratory. The concept of prior everyday knowledge is explained below under conceptual framework.

2.3. Conceptual framework

A conceptual framework was used as an analytical tool to assist in the answering of research questions. Key concepts such as prior everyday knowledge, language and science, practical activities, chemical reactions and meaning-making or sense-making were identified to provide a context for interpreting the study findings. The concepts give 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.

2.3.1. Prior everyday knowledge

Mortimer and Scott (2003) argue that learning science can be challenging for learners if there is a wide gap between their prior everyday knowledge and scientific knowledge. Prior everyday knowledge assists in the comprehension of new ideas and concepts (Roschelle, 1995; Oloruntegbe & Ikpe, 2011). For learners to be able to better construct new concepts in science, it is necessary for them to have some relevant prior knowledge and experiences, or to be able to find links to their everyday experiences (Stears, Malcolm & Kowlas, 2003; Oloruntegbe & Ikpe, 2011; Rennie, 2011). Thus, eliciting and integrating learners' prior knowledge in order to enhance conceptual development and sense-making becomes an imperative for teachers.

Learners are able to construct abstract concepts in science when these are drawn from relevant prior knowledge (Roschelle, 1995). Shizha (2007), during research on primary science education in Zimbabwe, found that teaching and learning of science in school was not successful because the subject was not linked to everyday life experiences. If learners do not see science education as something drawn from real-life, they are likely to experience alienation in learning it (ibid.).

In similar studies done in Nigerian secondary schools, Oloruntegbe and Ikpe (2011) concluded that it was imperative that teachers attempted to connect home activities with the teaching of chemistry in the classroom. This would make learning more meaningful to learners. Teachers should use familiar language and use phenomena from learners' daily life as examples in presenting chemistry materials. Concurring with this point of view, Rennie (2011) refers to this as closing the gap between prior everyday knowledge and school science. Similarly, Kuhlane (2011) asserts that educators should attempt to elicit the prior everyday knowledge that learners bring to the learning environment.

During a study with Grade 7 learners on acids and bases conducted in a school in the Eastern Cape Province of South Africa, Kuhlane (2011) revealed that the use of learners' prior everyday knowledge and experiences facilitated meaningful learning. It was found that linking learning to learners' everyday experiences enabled them to learn scientific concepts in a relaxed and non-threatening environment. Similarly, in a study conducted in Namibia on using equipment that is familiar with everyday contexts to support learning, the authors, Kasanda, Lubben, Gaoseb, Kangeo-Marenga, Kapenda and Campbell (2005) found that the conceptual attainment of the group that followed lessons infused with everyday contexts increased significantly. Teachers should be conscious of this link and should attempt to marry learners' everyday experiences with classroom practice (Rennie, 2011).

Oloruntegbe and Ikpe (2011) explain that the capacity to adequately educate learners in science can be achieved by taking into consideration what they experience in society and what the science curriculum provides during the learning process. Mukwambo et al. (2014) concur that pedagogic approaches to teaching and learning should capitalise on the cultural experiences learners bring to the classroom. Furthermore, they state that teachers' mediation of learning should be immersed in educational theories; relevant to the communities they are serving, historically and culturally. The key concept emerging is that learners bring with them prior everyday knowledge which teachers can use as a tool to unlock scientific concepts in the classroom. However, one should be aware that everyday knowledge may be flawed because of inconsistencies since learners come from different backgrounds and diverse experiences which may compromise the learning process.

Roschelle (1995) observes that prior knowledge can produce mistakes. Roschelle (1995) questions how learners construct knowledge from their existing concepts if their existing concepts are flawed. She, however, states that curriculum designers can work with prior knowledge despite its flaws. Prior knowledge is seen as providing flexible building blocks and science learning as the refinement of everyday ideas in a rich social context. Consequently, Roschelle (1995) advocates for caution as not all learning can lead to conceptual understanding. In agreement Meyer (2004) emphasizes that the knowledge from home establishes the base and the new scientific knowledge fortifies what they already know. Accordingly, these forms of knowledge complement each other. Moreover, Meyer (2004) reiterates that understanding by teachers of learners' current beliefs and experiences is of paramount importance. The pedagogic practices that teachers employ in classrooms should enable learners to organise concepts into structures that may be easily understood. If the learning environment is conducive and user-friendly, then the restructuring of new concepts will be made easy and this may result in successful learning.

Stears et al. (2003) recommend programme designs that build on learners' prior knowledge, interests and experiences. In their study the results showed that the use of everyday knowledge in the science classroom increased the levels of engagement of learners. Learners enjoyed making links between their different experiences when the curriculum is designed to facilitate such links. Meyer (2004) agreed with the importance of teachers being aware of their learners' prior experiences as well as prior learning and underscored the need for teachers to be convinced of the value of constructivist learning to fully engage learners in a constructivist environment (ibid.). Learners enjoy this process of linking new knowledge to old and of making new connections and meanings they can claim as their own (Kibirige & Van Rooyen, 2006).

To enhance meaning-making in science classrooms, Mortimer and Scott (2003) suggest a mature understanding of school science. They assert that teachers should have the ability to move between daily and school science views. Teachers should understand the similarities and differences between the two and attempt to draw from each as the lesson demands (ibid.) Various strategies may be employed by the teacher including the use of analogies to support learning and the use of question and answer techniques to elicit as much prior knowledge as possible. This interaction involves the use of language which is central in social constructivism, and it underpins the learning of chemical reactions in the classroom. The next section explores the role played by language in the science classroom.

2.3.2 Language and science

According to Mortimer and Scott (2003), science instruction involves introducing learners to new ways of knowing science. Learners need to be motivated to both appreciate and make new approaches of knowledge significant. Similarly, Sutton (1995) accredits the learning of science with offering new ways to communicate and the goal of science lessons being to offer learners a platform to practice this way of conversing. Lemke (1990) notes that the way the specialised language of science is used in the classroom could be a barrier to learning scientific concepts. Learners have to explore the natural world and make meaning of it in the classroom discourse so learning science may be difficult if learners do not have this important tool to make meaning in the classroom.

According to Mortimer and Scott (2003), science learning encompasses inducting the learners into the conventional principles of learning science. Again, Lemke (1990) posits that learning science is introducing the novice scientists to the language of science embraced by the scientific community. Lemke (1990) as well as Mortimer and Scott (2003) observe that scientific language is mastered in the same way as any other language and that it comes about through repeated use in context. This is a challenge for many learners, especially for those learning in a second language and teachers should beware of taking for granted that learners have understood the scientific concepts they have learned in every lesson. The language of science has to be given considerable attention since the language of learning and teaching is alien to the learners.

According to Probyn (2009), when English is used with English Second Language (ESL) learners to facilitate learning, it becomes a deterrent towards conceptual mastery. Probyn (2009) advocates code-switching in order to aid understanding in the teaching and learning process. Code-switching involves the teacher reverting to the vernacular language in order to explain abstract concepts. Besides code-switching, multiple instructional strategies are encouraged for better understanding of scientific concepts.

We communicate and understand our world through language. Much of human thought occurs through it (Vygotsky, 1978). Hence, learners' ability to think and learn depends on their ability to use and understand this crucial medium. According to Wellington and Osborne (2001), teaching in English may impede learners' success in learning. According to studies done on English as a language of learning and teaching (LoLT) when learners are not taught in the vernacular language, communication and mediation of learning may become very complicated.

English as a language has surpassed most languages in its development and it has emerged as "the language of access and power" (Probyn, 2006, p. 391). Various opportunities and hegemonic benefits are linked to it. That is why most science materials are written in the English language. The vocabulary and terminology is in English and this poses the biggest challenge to teachers. Teachers are supposed to build on learners' home language, however classrooms may be multicultural or metalinguistic in nature. It is possible to have learners that come from more than three language groups in the same classroom and the teacher may not be proficient in all of them which creates a dilemma for the teacher because of the language limitation.

Despite cited challenges, pedagogies have to be implemented to assist learners battling with the language of learning and teaching to comprehend scientific concepts. According to Probyn (2006) the English language dominates the political economy and is the medium of instruction used by the majority of South African schools. This, despite the fact that most learners do not have the opportunity to acquire the necessary English language proficiency required for effective engagement with the curriculum. Howie (2001) asserts that South African learners experience limitations with communicating their scientific and mathematical findings in the language used in examinations, especially ESL learners.

Language limitations of learners are made worse by science teachers who struggle to communicate in the language of learning and teaching. Learners according to Johnstone and Selepeng (2001) struggling to learn science in a second language lose at least 20 percent of their capacity to reason and understand in the process. One of the reasons for this loss is that learners do not have exposure to the language of learning. Another reason is the lack of an understanding of the scientific vocabulary and context specific learning. This leads to frustration caused by failure to see meanings in texts, leading to rote learning. Research shows that information obtained by rote learning is not retained in long memory (Eilks, Moellering & Valadines, 2007). Meaningful connection of new and old information becomes impossible and ultimately, the subject is labelled as 'difficult'.

According to Cummins (1992), learners who have not developed their Cognitive Academic Language Proficiency (CALP) are at a disadvantage in studying academic subjects and science in particular because this course requires an in-depth understanding of concepts acquired by reading textbooks, participating in dialogue and debate and responding to questions in tests. Scientific meaning is developed through proper use of language. In order to understand something one must be able to articulate it. Hence, the onus lies with the teacher to help learners articulate their ideas (Mortimer & Scott, 2003).

Language ceases to be a tool for communication if learners do not understand it. It becomes a barrier to the learning of science as the content of every scientific subject can be expressed in language (Lemke, 1990). Maselwa and Ngcoza (2003) state that code-switching to the vernacular language as a strategy to enhance science learning could be helpful. They concluded that science would be regarded as easier if it could be done in one's own language. Probyn (2009) notes that code-switching is a legitimate language strategy which helps learners to understand concepts better. Code-switching helps in preventing student alienation from science and also "reduces the stress of learning through a second language" (p. 133).

The use of code-switching by teachers has many pros and cons. The major drawback being that English (and Afrikaans) has remained the language of examinations. Examinations at all levels in the country are administered only in English and Afrikaans (Barry, 2002). Code-switching to this end disadvantages learners as they are assessed in English. Jawahar (2008), in a study of scientific literacy, conducted in schools in KwaZulu Natal Province of South Africa, argues that code-switching results in loss of scientific meaning to some words like, power, force and work; as they all are encompassed by a single term in isiZulu.

However, Probyn (2009) insists that educators' code-switching helps learners understand scientific concepts. Probyn (2009) advocates teaching strategies like repeating key terms and concepts, speaking slowly, using gestures and voice tone to support communication. The use of glossaries in science textbooks, giving learners an opportunity to express themselves in English, simple experiments to help learners to understand new vocabulary, encouraging peer learning are some language development strategies. Writing of reflections and journals give learners ample opportunity to practice communication in the language of learning and teaching.

Wellington and Osborne (2001) insist that all forms of language (reading, writing, hearing and talking) make learning science effective and more enjoyable and matter to science education. Teachers should use language to make sense of each topic in a particular way. The language of chemistry is new to the learners and topics are very abstract (Scott, 1998; Boo, 2002). Learners use their own language to put together a view of the subject and it is vital that this corresponds with the actual content of the subject. Hence, understanding and knowing the language of science is a vital component in constructing meaningful scientific concepts. Notably, Weick, Sutcliffe and Obstfeld (2005) note that sense-making entails “an issue of language, talk and communication” (p. 409).

Lemke (1990) says learning science also means learning to articulate it during practical action in the laboratory. Although the use of practical activities thrives in an interactive environment, they can be a useful tool to help teachers get ideas across to learners. The next section discusses the use of practical activities in meaning-making in science.

2.3.3. Practical activities

The experience of doing practical work entails getting a feel for materials, apparatus, events and phenomena and is a vital part of science education. Nevertheless, there is need to critically consider the value and authenticity of practical activities as some researchers, for example, Hodson (1990), have called it invalid for use in science education. In spite of Hodson’s critical look at practical work in school science, other studies (Gott & Duggan, 1996; Tiberghien, 2000; Miller, 2004; Woodley, 2009 & Miller 2010) have considered its strength in science education. Miller (2004) regards practical work as any form of teaching and learning which engages learners in observing or manipulating real objects and materials they are studying. This helps learners to acquire scientific knowledge for themselves and aids memory. The Chinese adage ‘I hear and I forget’ ‘I see and I remember’ ‘I do and I understand’ becomes relevant here.

Woodley (2009) supports the use of practical activities in science education. The author notes that practical work enhances conceptual understanding by assisting learners to develop important scientific skills and to help them to understand the process of scientific inquiry. As highlighted earlier, scientific concepts are abstract and challenge meaning-making (Boo, 2002). Abrahams and Millar (2008), elaborate that the purpose of practical work is to close the gap between the real world of objects, materials and events and the abstract world of thoughts and ideas. Embarking on practical work may be a prerequisite for learning to take place in the science classroom.

Miller (2004) regards science as a body of consensually accepted knowledge about the natural world. To teach it is a goal oriented activity meant to bring learners’ ideas and understanding closer to those of the scientific community. Hence, Miller (2004) asserts that learning science should be an induction into a particular view of the world. Miller (2004) adds that practical work is capable of developing learners' scientific knowledge and as well as understanding the nature of science.

Furthermore, Miller (2004) explains that in some classroom situations practical activities are essential and cannot be replaced. This is when practical work is used in science classes when learners have not seen the phenomenon before or have not observed it adequately to make meaningful sense in their everyday lives (ibid.). It follows that the use of practical activities may be a vital link between classroom science and learners' every day prior knowledge. For example, a practical activity may be conducted to show the fermentation process (a chemical reaction) using traditional ways of brewing beer. Duckworth (1990) points out that the common aim of practical activities is making the learners think as well as to act. In addition, effective practical tasks are those that engage learners hands-on as well as minds-on (ibid.).

According to Maselwa and Ngcoza (2003), the use of 'hands-on', 'minds-on' and 'words-on' practical activities enhance learners' understanding of scientific concepts. Woodley (2009) as well as Miller (2010) posit that practical work is also a 'hands-on' learning experience which prompts thinking about the world and helps learners' progress in science education. Woodley (2009) insists that effective practical activities build a bridge between what learners can see and handle (hands-on) and scientific aides that account for their observation (brains-on). This link results in sense-making as it connects the abstract with the concrete (Weick et al., 2005).

According to Hodson (1996), the use of practical activities helps in the process of conceptual understanding. However, Hodson (1996) notes that conceptual knowledge and knowledge about procedures that scientists may adopt are insufficient in themselves to enable learners to engage successfully in scientific enquiry. Hodson (1996) believes in developing ability through the hands-on experience of doing science in a critical and supportive environment.

Wellington (1998) posits that children have a natural curiosity of the world around them. Much of what they learn is by observation and manipulation of it in various ways. Tapping into their curiosity through practical activities is a noble thing as this allows them opportunity to extend their knowledge in a way which seems natural and developmental (ibid.).

Gott and Duggan (1996) state that the teaching of science using practical work should be done carefully and with a clear purpose in mind of what needs to be achieved. A badly chosen practical exercise can be a waste of learners' valuable time. This is supported by Miller (2010) who maintains that effective practical tasks may be used as a method to scaffold learners' thinking. This calls for effective planning on the part of the teacher. Planning is essential in how to use practical work as well as making it most effective.

It is recognised, however, that some aspects of science education do not suit the use of practical activities. That is the reason why Hodson (1990) asserts that the use of practical work is a ‘waste of time’. Hodson (1990) claims that most practical activities are ill-conceived, muddled and of little educational value. Hodson’s (1990) claim may hold water in instances when there is inadequate preparation for the practical task. The goal of doing practical work should be clear from the start. This calls for prior planning as learners are motivated to learn and be engaged in practical tasks when explicit instructions are given.

While various teaching methods can be used in sense-making of scientific concepts, practical work has a key role, provided the type of practical work is selected carefully with a clear purpose in mind (Gott & Duggan, 1996). Practical work for its own sake is no longer sufficient justification and other vital strategies can be used to help learners understand science. However, the use of practical activities is still relevant today. Observable phenomena like a bubbling change, a smelly change or a change that gets hot makes sense to learners engaged in practical activities. These changes, sometimes accompany a chemical reaction, the next key concept to be explained.

2.3.4 Chemical reactions

Most teachers agree that chemistry is difficult for learners because of the abstract terms used to describe concepts in the subject. Nakhleh (1992) comments that understanding chemistry in the mediation of learning is not an easy task as learners find the terms difficult to grasp. In the same vein, Calik and Ayas (2005) note that because of its complexity to teach and learn, chemistry is among the most investigated topics. Johnson (2000) acknowledges that learners’ comprehension of concepts pertaining to chemical change is very poor. Nakhleh (1992) observes that many learners do not have proper understanding of basic chemical concepts from the start of their studies, hence they find the subject difficult in later years.

In their study on learners’ conceptions of chemical change, Hesse and Anderson (1992) acknowledged the complexity of chemical change. They add that learners comprehend chemical reactions through observing phenomena such as fizz, explosion, or change of colour but have problems in describing these events in terms of the combination of elements (ibid.). The above findings are further justifications for this research which focuses on the difficulties learners face when they are introduced to chemical reactions in the initial stages of their learning of chemistry.

According to Hesse and Anderson (1992), chemistry is mostly the descriptions and explanations of chemical changes. They add that learners usually find it difficult to comprehend chemical changes as they happen in the natural world. This is supported by findings from a plethora of studies (Garnett, Garnett & Hackling, 1995; Johnson, 2000; Calik & Ayas, 2005) who have consistently indicated that there is poor understanding of chemical changes and confusion between physical changes and chemical changes. This confusion may be the reason why so few learners pursue Physical Sciences at Grade 10 (in our context) and later at tertiary level. Finding the subject difficult at an early stage of learning is quite de-motivating. Both physical and chemical phenomena have to be explicitly clear to learners from the beginning.

Physical change or phenomena entails changes in the state of a substance that results in no new substances or substance being produced (Tsaparlis, 2003). Examples of physical phenomena include boiling, melting re-crystallization and breaking or deformation of a material. In a chemical phenomenon, however one (or more) new substances is produced (Tsaparlis, 2003). Examples of chemical changes include, burning, rusting of iron and action of an acid on a material. Some of the examples of physical and chemical changes are closely connected to everyday life experiences yet their everyday meanings differ from the scientific meaning.

However, Hesse and Anderson (1992) indicate that everyday notions including the language of learners may impede or distort the meaning of scientific terms. In their studies, learners treated changes such as rusting as physical changes in form or state and in addition considered rusting as something like decay. Similarly, in studies conducted in Greece, the problem arises from the different use of the term ‘physical phenomena’ in everyday language as phenomena that occurs naturally (natural phenomena) (Tsaparlis, 2003). In colloquial Greek, ‘physical phenomena’ means natural phenomena, resulting in the interference of everyday language in the operation of scientific concepts (ibid.).

The majority of students use everyday notions about burning instead of scientific concepts (Hesse & Anderson, 1992). Boo (2002) concurs that some learners thought that burning could take place without oxygen, because the everyday understanding of the term is catching fire. Underlying problems reside in some learners’ conceptualisation of burning that arises directly from a differing use of terms in science and everyday language. While ‘burning’ has a precise meaning to a chemist, in everyday language it is used to express a number of different ideas;

for example, set alight, catching fire, application of excess heat (sun-burn) and destruction by fire (ibid.). In addition, Johnson (2000) points that learners find it difficult to comprehend that a solid such as copper can combine with a gas such as oxygen. Consequently, the information that learners bring to the science lesson may make comprehension of scientific concepts complicated. According to Nakhleh (1992), physical and chemical changes are the foundation for understanding many chemical concepts. Johnson (2000) is of the opinion that the prior everyday knowledge chemical science learners bring in the classroom is crucial to their assimilation of scientific concepts.

According to Nakhleh (1992), the information learners use to construct concepts comes from two sources. Namely public knowledge as presented in texts and lectures and informal prior knowledge from everyday experiences, parents, peers, commercial products and the common meanings of scientific terms. Nakhleh (1992) maintains that the occurrence of misconceptions may be due to the fact that learners have meanings for everyday words that are different from the scientific meaning. Hesse and Anderson (1992) note that many learners demonstrate a preference for explanations based on superficial analogies with everyday events (for example, rusting is like decaying) over explanations based on chemical theories. These preferences have led to loss of sense-making when learning science, particularly chemistry.

Furthermore, Tsaparlis (2003) adds that learners intuitively make use of everyday ideas to explain chemical changes. In addition, learners maintain that something is conserved, despite changes in appearances. Studies done by Hesse and Anderson (1992) support this by identifying events where learners could not predict or explain mass changes in chemical reactions involving iron. In their study, learners treated chemical changes such as rusting as physical changes and failed to understand the role of reactants or products in the reactions (in this case gaseous).

In their studies with different age groups, Stavridou and Solomonidou (1998) found that 14 and 16 years old learners experience difficulties when trying to understand chemical reactions. They reported that the 14 years old learners did not understand chemical reactions as changes, but as ‘events’ with some phenomenological manifestations, e.g. colour changes, gas release and explosion and 16 years old learners found distinguishing between different kinds of changes difficult.

Furthermore, Stavridou and Solomonidou (1998) state another misconception arising in the learning of chemical reactions when there are two products in the initial stage. Learners regard this as a chemical reaction. Thus, the solution of sugar in water and the boiling of water are also regarded as chemical reactions when they are not. The reason learners develop this conception is because the majority of the examples of chemical reactions presented in textbooks or practised in school laboratories have two initial products.

Nakhleh (1992) explains that most learners have a weak conception of the model of matter: matter composed of small, mobile particles such as atoms, molecules and ions. According to Hesse and Anderson (1992) for learners to be able to explain a chemical change, understanding of a variety of facts pertaining to the chemical properties of the substances involved is imperative. Hesse and Anderson (1992) add that using the word reaction by learners was regularly found in learners' explanations, yet these learners demonstrated little understanding that reactions involve the interaction of atoms and molecules. Although learning of atoms and molecules are in the curriculum, most learners failed to invoke them as they have been emphasised in the chemistry course (ibid.). Tsaparlis (2003) notes other forms of misconception were taking the evolution of a gas and frothing as indicators of chemical reaction(s). These misconceptions of learners in learning chemical reactions require further attention in most textbooks as well as in the curriculum.

Despite hiccups in prior everyday knowledge in making sense of chemical reactions, Anderson (1986) points out that learners understand something new with the help of existing knowledge. Anderson (1986) urges that the more teachers know about these conceptions, the better they are able to provide learning experiences that stimulate learners to modify their initial conceptions. This is in agreement with the constructivist view of learning. Anderson (1986) elucidates that using the constructivist view of learning, learners' attempt to comprehend something new by assimilating it into existing cognitive structures. The new information is organised and by doing and talking as a necessary consideration, this leads to increased understanding (Ash, 2004). This entails careful use of language and setting of activities of the classroom in order to enhance meaning-making of chemical reactions. It also has implications for creating an environment where learners are given the opportunity to construct their own knowledge. This idea is explained in more detail in the discussion of the theoretical framework underpinning this study.

Hesse and Anderson (2006) point out that not only environment changes that are necessary but changes are also needed in many aspects of chemical education, including textbooks, written materials, classroom teaching and teacher education programmes. Johnson (2000) lays the blame for the difficulty in understanding chemical changes on curriculum designers for failing to deal properly with the relevant concepts. Johnson (2000) further argues that the curriculum does not address the key ideas that learners lack and need to develop in order to understand standard chemistry content. Furthermore, Johnson (2000) notes that something is missing in the teaching and learning of chemistry in schools when he observes that the curriculum is not designed from the perspective of the learner as it makes sense only for those who already understand chemistry. Johnson (2000) concludes his argument by stating that learners' difficulties with chemistry are symptomatic of a curriculum where important ideas are missing. Thus, curricula should directly address key concepts to enhance meaning-making in science, which is a major component of this research.

2.3.5. Meaning-making or sense-making in science education

Mortimer and Scott (2003) write extensively on different kinds of interaction between teacher and learners (including those between learners) in science classrooms and how these can contribute to meaning-making and learning. They perceive the concepts as a dialogic process, where different ideas are brought together and acted upon. This happens when the teacher is working with learners in the class, a parent or an adult explaining something to a child or a group of friends conversing with each other. Mortimer and Scott (2003) observe that new ideas are met first in social situations where the ideas are shared between people, drawing on a range of communication, such as talk, gesture, writing, visual images and action (ibid.) Vygotsky (1978) refers to these interactions as existing on the social plane.

Mortimer and Scott (2003) further develop the idea of the social plane by stating that as individuals share and reflect during social interaction, the individual is able to make sense of what is being communicated. The words, gestures and images are used as tools for individual thinking. Thus, there is a transition from social to individual planes (Vygotsky, 1978). Thus, learners learn science as they interact with the teacher and each other on the social plane and finally make sense of scientific concepts as individuals.

Mortimer and Scott (2003) argue that the process of internalisation by learners always involves working on ideas they already have. Meaning-making or learning progress is easy if there is no tension between existing and new views so sometimes conflict arises if new ideas need to be integrated into existing knowledge, and this calls for the dialogic process, through classroom talk. They urge that classroom talk matters as it is central to the meaning-making process and thus central to learning. Similarly, Weick et al. (2005) note that sense-making encompasses transformation of circumstances into situations that are easily understood in words and that serves as a starting point into action.

With this in mind, Mortimer and Scott (2003) point out that it is through teacher and learner talk around the activities that science teaching and learning can occur as classroom talk enables the learners to engage consciously in the dialogic process of meaning-making and provides tools for them to think through scientific views for themselves.

In addition, McRobbie and Tobin (1997) agree that if learning is regarded as a process of making sense of experiential reality in terms of existing knowledge, the role of the teacher is significant. This role must be directed toward influencing the experiential reality and providing opportunities for learners to bring forward their previous experience in the process of sense-making. This could happen in a social constructivist environment where learners have control over their own learning (McRobbie & Tobin, 1997). They add that social constructivism recognises the importance of social and personal aspects of learning. They state that meaning is constructed by individuals as new information interacts with existing knowledge. This claim supports the importance of prior knowledge in the learning process, as discussed earlier in the study.

Findings from studies conducted by Howe (1996), Stears, Malcolm and Kowlas (2003), Oloruntegbe and Ikpe (2011), Rennie (2011), and Kuhlane (2011) show that learners do not come into science instruction without any pre-instructional knowledge or beliefs about the phenomena and concepts to be taught. Duit and Treagust (2003) argue that learners hold deeply-rooted conceptions and ideas that are not in harmony with scientific views or are even directly opposite to them. They note that for meaning-making to take place in learners, their pre-instructional conceptual structures have to be fundamentally restructured. This enables the understanding or acquisition of science concepts. In order for this to happen, science teaching and learning should happen in a social constructivist environment. This study is informed by a theoretical framework of social constructivism, which is discussed below.

2.4. Theoretical framework

According to Mouton (1996), a theoretical framework guides and directs the research process. It provides a structure for organising and supporting the researcher's ideas (Leshen & Trafford, 2007). Merriam (2009) notes that all aspects of a research study are affected by its theoretical framework. This framework typically consists of a body of literature that can be drawn upon in the research process and point the reader to the issue(s) being studied (ibid). The theoretical framework in this study is social constructivism.

2.4.1. Constructivism

Vygotsky (1962) believes that constructivist-based instruction places educational priorities on learners' learning. Vygotsky (1962) views constructivism as a theory of learning that lays emphasis on the notions that people learn and acquire knowledge through active engagement, inquiry, problem solving and collaboration with others. Lending support to this perspective, Jones and Brader-Araje (2002) assert that the common thread that runs through the many definitions of constructivism is the concept that the development of understanding requires learners' active engagement in meaning-making.

Constructivist teachers recognise that by the time learners commence school, they have already acquired a huge knowledge bank for their own explanations of the world. They have picked up these ideas from all sorts of experiences, events, people, places and ever-present media. Constructivist learning theory recognises that learners come to chemistry lessons having alternative conceptions already formed because of the interaction they have had with the environment (Boo & Watson, 2000). Teachers should therefore be aware of the role of prior knowledge in learners' learning and recognise that learners are not blank slates waiting to be filled with knowledge (Jones & Brader-Araje, 2002).

Jones and Brader-Araje (2002) caution that learners bring to school a variety of preconceptions tied to prior experience that may be very resistant to change. These preconceptions are based on learners' early experiences. Teachers should use several instructional strategies, starting with finding out what learners know, in order for understanding to take place. Teachers must not only elicit learners' prior knowledge, but must also build on the concepts learners already have during instruction (ibid.).

Language is key to the actualisation of conceptual growth to take place. (Section 2.3.2). Vygotsky (1978) reasons that the construction of meaning happens in a social context via language and through exchanges with other people, either directly or indirectly, via books, movies and so on. Children use language as a tool for problem solving (Vygotsky, 1978). Constructivism's emphasis on the role of language in learning has shifted teachers' teaching strategies toward a concentration on language as a tool in learners' meaning-making processes (Jones & Brader-Araje, 2002). Learners solve practical tasks with the help of speech, as well as their eyes and hands (Vygotsky, 1978).

2.4.2. Social constructivism

The most significant strand of social constructivist theory was introduced by Vygotsky in his notion of the 'Zone of Proximal Development' (ZPD). Vygotsky (1978) defines the ZPD as the "difference between the actual development reflected by individual problem solving and the level of potential development as mirrored by what a learner can do under teacher guidance or in collaboration with more able peers" (p. 86). Vygotsky (1978) observed that when children were tested on tasks on their own, they rarely did well as when compared with working in collaboration with an adult. For Vygotsky social relationships are crucial in the mediation of learning. Thus, social constructivism can be said to be the act of acquiring knowledge or making meaning in the course of social relationships. One important aspect of the social constructivist notion to note is that it consists of situated learning where learners are engaged in activities which are familiar and directly relevant to their real life, activities which happen within a culture related to an everyday setting (Brown, Collin & Duguid, 1989).

Monyai and Nieman (2006) assert that social constructivism is an active process of constructing meaning. They note that learning is learner centred, social and occurs within a context. They emphasise the role of social process in learning, including group activities with peers. Learners should be given opportunities to construct knowledge as they interact in their social context. McRobbie and Tobin (1997) also recognise the importance of social and personal aspects of learning in social constructivism. They assert that meaning is constructed by individuals as new information interacts with existing knowledge. The quality of prior everyday knowledge is vital. If it is flawed, then misconceptions are likely to occur in the learning of science.

Of central interest in social constructivism are its concepts of the involvement of learners, autonomy and relevance. McRobbie and Tobin (1997) insist on the involvement of learners in discussions with each other. They report that listening to and making sense of the ideas of other learners enhances learning. They further suggest active involvement in tasks associated with making connections with experience and extant knowledge. Bringing about change through these connections involves the use of language. McRobbie and Tobin insist that it is necessary to have a language of learning common to both the teacher and learners so that together they can discuss and understand issues in science learning. This development in communication is termed 'talking science' by Lemke (1990). It means doing science through the medium of language (ibid.), a significant theme in this framework.

Additionally, McRobbie and Tobin (1997) maintain that in the social constructivist perspective on learning, learners should have control over their own learning. Our role as teachers is to provide guidance and support to learners in the form of 'scaffolding' (Wood, Bruner & Ross, 1976). This is "interactive verbal support provided by peers, teachers and family that guides a learner through the zone of proximal development (ZPD) and enables learners to carry out tasks that they would be unable to do without help" (Vygotsky, 1978, p. 86). The newly generated meanings are then actively linked to the learner's prior knowledge base (Nakhleh, 1992). Constructivism emphasises the importance of scaffolding learners' learning and encouraging their active involvement in a suitable environment so as to develop 'new' understandings or meanings in the science classroom (Donald, Lazarus & Lolwana, 2002; Monyai & Nieman, 2006). Donald et al. (2002) reiterate that scaffolding cannot be successful unless it connects with what is familiar to learners in their current environment.

According to McRobbie and Tobin (1997), making the science curriculum relevant for all learners is essential. Learning is enhanced if learners can link what they know to what they are to learn. This link should be in terms of their everyday lives and interests. The CAPS document for senior phase aims to produce learners who understand the uses of Natural sciences and indigenous knowledge in society and the environment (DoE, 2011). The familiar form can be combined with unfamiliar content to facilitate the process of connecting in the ZPD (Donald et al., 2002).

However, learners' everyday experiences are not given much consideration in lesson planning. In most classrooms, teaching and learning are still teacher-centred. The teacher decides on which practical activities to do and what is going to be taught, on the time to learn and when to split into groups. Finally, the teacher decides on how and when to assess the learners' progress. Traditional patterns of teaching like this should be shunned in favour of learner-centred pedagogies. Prevalent strategies include forcing learners to memorise (scientific concepts), pushing them too fast to cover prescribed content in the curriculum, and assuming that the teacher is the only source of knowledge. Such strategies defeat the spirit of social constructivism. Learners should be given opportunities to bring forward their prior knowledge in the process of sense-making.

Bodner (1986) insists that "anyone who has studied chemistry, or tried to teach it to others, knows that active students learn more than passive students" (p. 873). A social constructivist perspective on learning highlights the role of active involvement in tasks associated with making connections between experience and extant knowledge (McRobbie & Tobin, 1997). Donald et al. (2002) add that active learning needs to involve a variety of activities as what is taught and how it is taught are equally important, and that both "learning and cognitive development are not passive but active processes" (ibid., p. 90).

2.5. Concluding remarks

The key conceptual frameworks discussed in the literature have pointed to the value of prior everyday knowledge in the learning of science. Practical activities, chemical reactions, language and science, meaning-making, prior everyday knowledge and the CAPS document have all pointed to the use of prior everyday knowledge as a tool to help enable the understanding of scientific concepts. Prior everyday knowledge may be flawed but its usefulness in the learning of science cannot be ignored. The proper use of language and practical activities, within an interactive environment, have emerged as key tools in the learning of chemical reactions.

The theoretical framework of social constructivism was discussed and it emerged that learners construct their own knowledge when they are actively involved in science learning. Teachers should employ pedagogical methods that promote the active involvement of learners in their own learning. The social constructivist view of learning takes into account the quality of ideas learners bring to the learning environment. Learners' experiences are largely determined by the language and culture with and in which they have grown up.

The next chapter discusses the methodology employed in the study.

CHAPTER 3: METHODOLOGY

3.1 Introduction

The goal of this study was to investigate how Grade 8 learners make sense of chemical reactions when using familiar resources, the intention being to improve the mediation of early learning of chemical reactions at high school level. The topic has proved to be challenging to learners and this may be a contributing factor as to why some learners shun Physical Sciences at Grade 10 level.

An interpretative paradigm was used together with a constructivist framework to study how Natural Sciences learners make sense of chemical reactions during lessons using familiar resources. The research project began with learners writing a diagnostic test in order to reveal their prior knowledge on the topic of chemical reactions. Based on their choice of answers in the diagnostic test, purposive sampling of learners was conducted to select learners that constituted the focus group. An intervention in the form of a participatory approach to teaching, involving the use of familiar materials, followed. The teachers' lessons were videotaped and learners completed worksheets which were then analysed to identify how the learners make meaning of the concepts. The validation process was addressed using triangulation, checking interpretations with the focus group interviewed. Ethical considerations included anonymity to ensure confidentiality of participant's identities.

3.2 Research design and orientation

The research occurred in two phases and adopted the mixed methods approach. According to Creswell (2003), collecting and analysing data using both qualitative and quantitative approaches is one of the defining characteristics of a mixed approach research. Cohen, Manion and Morrison (2011) confirm that a mixed method approach is an immersion of qualitative and quantitative data. Addressing the social processes was a crucial component of this study.

The research used both quantitative and qualitative approaches as data was collected from diagnostic tests, completed worksheets during the interventions and in summative tests which were numerical. Terre Blanche, Durrheim and Painter (2007) argue that researchers within the quantitative paradigm deal with numbers and statistics as their data. Furthermore, the study employed interviews which are data collecting tools in qualitative research. The study made use of the interpretive paradigm.

3.2.1 Interpretive paradigm

The research is a qualitative case study which aimed at attaining an understanding of the sense-making of chemical reactions by learners within one Natural Sciences classroom. It employs an interpretive paradigm which focuses on individuals in order to understand the bigger picture (Terre Blanche et al., 2007; Cohen et al., 2011). In addition, McKernan (1996) further argues that the interpretative paradigm takes cognisance of the intricacies of the society which are read through the actions of the individuals. The use of the paradigm assisted the researcher in exploring how learners make sense of chemical reactions when familiar resources are used.

In order to answer the research questions, lessons were presented and videotaped by the participant researcher. An interview with one focus group was conducted and videotaped by a Master of Education Rhodes University student teaching at the school. The original plan was to observe the participant researcher mediating learning, but she later changed her mind citing the fact that she found the strategy of parallel presentations of using familiar resources and conventional chemicals in the same lesson difficult. She suggested that the researcher rather teach the lesson while she videotaped it. Lessons were planned collaboratively as the researcher and the participant researcher intended to produce a unit of work on the topic at the end of the research process.

Each lesson presented involved two steps. The first step was engaging learners in a lesson involving practical activities using everyday familiar resources. The second step was using conventional chemicals from the science laboratory. Learners completed worksheets after lesson presentations. Learners' responses were analysed and a follow-up of responses was done using the focus group interview.

The use of interviews was necessary in order to get the focus group to elaborate on their responses and constituted a source of data on the effects of learning using familiar resources in practical activities. The approaches were in line with the interpretive framework underpinning this study.

Moll (2002) advocates a learning environment where learners construct knowledge in social settings which is part of a theory called social constructivism. Concurring with this idea, Creswell (2007) argues that personal meanings are negotiated historically and socially by individual learners as they interact with others. Moll (2002) emphasizes the role of social processes in learning, including group activities with peers. Moll (2002) argues that learners should be given opportunities to construct knowledge as they interact in their social context.

Learners were engaged in small groups and they were made to complete worksheets in order to obtain data and the learner worksheets, focus group discussions and interviews were vital sources of information.

3.2.2 Qualitative case study research

According to Merriam (2009), qualitative research attempts to decipher how people live their lives and interpret their experiences. Since one of the research question involved investigating meaning-making and understanding of concepts related to chemical reactions, this is consistent with a qualitative case study, where meanings are investigated. Within the research framework a case study approach was adopted.

Creswell (2007) describes case study research as an in-depth analysis of a case under study over a stipulated period of time. Data gathered from the case is organised and arranged into themes for analysis. Cohen et al. (2011) perceive case studies as recognising and accepting that there are numerous variables in action in a single case, so catching the implications of the variables usually requires more than one tool for data collection and many sources of evidence. In this study, the researcher analysed learners' worksheets, learners' reflections, mind maps, conducted interviews with the focus group as well as a stimulated recall interview. The use of multiple techniques rendered a case study approach suitable for the research.

Terre Blanche et al. (2006) indicate that modern case studies make use of video and audio recording devices to store data for further analysis. Case studies according to Cohen et al. (2011) are capable of penetrating situations in ways that are not always susceptible to numerical analysis. This is supported by Yin (2009) who affirms that case studies are capable of blending numerical and qualitative data. Case studies are models of mixed methods research as they are capable of illustrating, describing and enlightening so proved was appropriate for this research as it utilised a mixed approach to produce penetrating accounts of the actions and thoughts of learners during mediation of the topic chemical reactions.

Freebody (2004) posits that the uniqueness of case studies is that they focus on one particular instance of educational experience and attempt to gain theoretical and professional insights from a full documentation of that instance. This study focused on meaning-making in the early learning of chemical reactions in Natural Sciences. Meaning-making is the most elementary part of the phenomenon studied described as the unit of analysis (Nachmias & Nachmias, 1996). One Grade 8 class was the focus of the study; the case, and sense-making of some concepts of chemical reactions was the unit of analysis.

3.2.3 Designing a teaching unit of work

Learning materials are central to instruction and one of the most vital influences on the mediation of learning (Kitao & Kitao, 2014). Kitao and Kitao (2014) suggest that it is only in using materials in teaching and learning interactions that the materials become ‘useful’ and meaningful. In this study, the researcher designed a teaching unit of work with the participant researcher as a tool in the mediation of the topic, chemical reactions. The unit of work was informed by the learners’ responses to the diagnostic test and the CAPS document.

The unit of work consists of three lesson plans. They were designed to incorporate resources the learners were accustomed to and conventional chemicals in the same lesson. Parallel lessons were planned starting with the lesson using familiar resources, followed by a lesson using conventional chemicals. The reason for designing lessons that way was to check the impact of familiar resources and conventional chemicals from a laboratory on sense-making. Learners were engaged in mediated activities in small groups. The following overview describes the constituents of the lessons in the unit of work:

Lesson 1: Oxidation of iron and magnesium

The lesson comprised two steps. The first step consisted of demonstrating the oxidation of iron using familiar resources. The researcher brought mathematical sets casings which were severely affected by rust together with cases which were new into the classroom. The apparatus showed learners an everyday example of chemical change. The mathematical casings are made of iron. Learners were engaged in a question and answer session about the rusting of iron, stating and explaining observations of the reactions. Prior everyday knowledge was elicited and integrated during the discussions. In the lesson iron was oxidised to iron oxide.

The second step of the lesson involved learners in the practical activity of burning magnesium ribbon. Magnesium is a conventional chemical. The burning of magnesium helped learners to observe chemical change using conventional chemicals. Observations of chemical changes determine some characteristics that can be used as evidence of a chemical change. During the activity, learners shared their views in groups and were engaged as a class during question and answer discussions. They were given worksheets to complete questions on oxidation of iron and oxidation of magnesium (Appendix G1).

Lesson 2: **The egg/vinegar reaction and hydrochloric acid/calcium carbonate reaction** (Appendix H).

An egg was placed in vinegar and left for a period of fifty hours. Learners could observe everyday chemical reactions. They were familiar with both an egg and vinegar. A parallel lesson on chemical reactions between a carbonate and an acid is prescribed in the CAPS document. Egg shells consist of 98% calcium carbonate and vinegar is an acid. Learners dropped a few drops of hydrochloric acid into powdered calcium carbonate. They shared observations and completed worksheets (Appendix H1).

Lesson 3: **Making lemon tea and blowing into clear limewater**

The lesson (Appendix I) required learners to observe colour change in both phenomena as prescribed in the CAPS document. Learners were required to make black tea and add lemon (everyday phenomenon). This was followed by the effervescing into lime water practical activity. Limewater is an example of a conventional chemical. Learners used plastic straws to blow bubbles into limewater in the test tube. Learners discussed whether the activities were examples of a chemical or physical change. Learners were also asked to share their observations about colour changes. Worksheets were completed at the end of the lesson (Appendix I1).

The objective of designing the unit of work (Appendix R) was to support the mediation of learning of chemical reactions by addressing misconceptions identified in the diagnostic test. The unit of work is interactive in nature and recognises that learners' conceptual knowledge of chemical reactions may be based on a model of learning in which learners construct their own concepts. This is in line with the theoretical framework of this study, social constructivism (Vygotsky, 1978), to be discussed in detail later. In addition, the unit of work was designed to answer the main research question on how Grade 8 learners make sense of chemical reactions when using familiar resources. The CAPS document challenges teachers to consider learners' cultural context (DoE, 2011) during the teaching and learning process to assist conceptual understanding.

The traditional curriculum focuses on the teacher rather than the learner (Donnelly & Fitzmaurice, 2005) and these authors recommend a shift from a teacher to a learner-centred curriculum. Thus, to fit with this, the unit of work incorporated practical activities using familiar resources as a teaching tool. It encourages learners' deep engagement and gives them an opportunity to construct knowledge as they interact in their social context. The newly generated meanings are then actively linked to learners' prior knowledge base to assist meaning-making as described in the literature. The process of producing the unit of work was a difficult one.

For instance, it was a challenge for the two developers to meet regularly as learners were writing examinations. Consequently, the researcher took the leading role in the designing process. A meeting was later arranged to amend the document. In designing the unit of work, the participant researcher and the researcher formed a community of practice. This is a collaborative relationship attempted to address misconceptions in the early learning of chemical reactions via teacher interventions before they become problematic in later grades.

3.3 Research goal and questions

3.3.1 Research goal

To investigate how Grade 8 learners make sense of chemical reactions during lessons using familiar resources.

3.3.2 Research question

Main research question:

How do Grade 8 learners make sense of concepts in chemical reactions during lessons using familiar resources?

Sub-questions:

- How do Grade 8 Natural Sciences learners make use of prior everyday knowledge to construct their understanding of chemical reactions?
- To what extent do practical activities involving familiar resources enhance or constrain the learning of chemical reactions in Grade 8 Natural Sciences lessons?
- Which concepts related to chemical reactions do Grade 8 Natural Sciences learners find difficult?

3.4 Research site and participants

3.4.1 Research site

The research site was Mazondo (pseudonym) high school, in the Eastern Cape Province. It is a public school with the majority of learners living in the township and a few coming from surrounding farms. The language of learning and teaching (LoLT) is First Additional English (FAL) and isiXhosa is the learner's home language (mother tongue).

The selected school has a record of producing good results, far better than the under-resourced high schools in the Grahamstown district and learners at the school are encouraged to maintain high standards of academic performance by participating in after school lessons offered by Rhodes University. The majority of the teachers are qualified by South African standards. Where there is a teacher shortage, graduate unqualified teachers (without normative qualifications) are employed, especially when needed for teaching mathematics and first additional English. The school is well resourced with a fully furnished computer laboratory for learners. It was selected as the research site because of easy accessibility for the researcher.

3.4.2 Sampling

Two forms of sampling, namely, purposive and convenience sampling were used in the research. According to Merriam (2009), purposive sampling is closely linked to qualitative studies as it focuses on phenomena that occur in a natural setting. Additionally, Boeijie (2010) describes purposive sampling as a sample comprising the cases that will be investigated and are selected from a defined population. The sample was intentionally selected according to the needs of the study (ibid.). The purposive strategy also guided the choice of the participant researcher and the school.

The rationale of choosing a Grade 8 class as the case was that it is here where the topic, chemical reactions is introduced.

As mentioned above, it is essential that learners construct the appropriate understanding of fundamental chemical concepts from the very beginning of their studies (Nakhleh, 1992). According to Boeijie (2010), studying small samples enables an intensive study of cases and this generates large amounts of information from those who possess it. Furthermore, the sampling was purposive because a class that could benefit the most from this study was selected. Cohen et al. (2011) point out that during purposive sampling, hand-picking is done by researchers. The researchers decide who should be included in the sample on the basis of their judgement of their typicality or possession of the particular characteristics being sought.

In this study, sampling was conducted based on the diagnostic test responses by learners. Chemical misconceptions and difficulties in recognising and describing physical and chemical change indicated some of the criteria for selecting learners with whom semi-structured interviews were conducted. Interviews were used as a tool to uncover misconceptions.

The school was selected first so the Grade 8 teacher automatically became the participant researcher. The participant researcher has thirteen years of teaching experience, and holds a standard teaching diploma (STD), Advance certificate (ACE) in science and Bed (Honours) in education. This is her second year of teaching Natural Sciences. Her subject specialisation is Life Sciences and she is accustomed to teaching grades 10-12 learners. She acknowledged that the chemistry component in Natural Sciences was new to her so the research study was advantageous to both the researcher and participant teacher. Convenience sampling was used in the study.

Convenience sampling refers to choosing the sample according to easy access by the researcher (Cohen et al., 2011). Therefore a high school next to the researcher's school was chosen on the basis of expediency. This in turn made the data gathering process easier as the researcher had convenient access to the school.

The class comprised 32 learners, 18 girls and 14 boys. (Appendix B). Fourteen learners were involved in the pilot study during their Grade 7 year at the researcher's school. They were involved in the writing of reflections on demonstrations of chemical reactions by the Chemistry Department of Rhodes University in order to gain insight into misconceptions as well as challenges faced when mediating the topic chemical reactions. Merriam (2009) advises that during an in-depth study of a case, a single case is sufficient. As the researcher was carrying out a case study for a half-thesis, a sample of thirty-two learners was considered adequate. In order to ensure that the study was trustworthy, however, several data gathering tools were used.

3.5 Data gathering techniques

In the first phase of the research, the researcher used diagnostic test responses, learners' worksheets from presented lessons, summative test responses and focus group interviews (semi-structured and stimulated recall interviews) as data collection methods. In the second phase, a unit of work was developed to help the teaching of chemical reactions.

The above techniques were used successfully and the data generated is discussed in the next chapter. The table below outlines the various stages of the research process.

Table 3.1 : Phases and stages in the data gathering process

Phase one	**Methods used to gather data**	**Data gathered**	**Purpose**
1	Pilot study of diagnostic questions and interview questions	Learner's experiences and perceptions on set questions.	To assess suitability and quality of questions.
2	Analysis of the diagnostic test.	Learners' prior knowledge on chemical reactions.	To gain insight into the prior everyday knowledge on chemical reactions learners bring into the classroom.
3	Lesson presentation and analysis of worksheets.	Learner's meaning-making of chemical reactions.	To gain insight into sense-making when learners are using practical activities on learning. To gain insight into the possibilities of intervention to improve the mediation of learning.
4	Semi-structured interviews.	Learners' perceptions of mediation of abstract concepts in science.	To gain insight into how learners make meaning in the learning of chemical reactions.
5	Summative test.	Learners' responses on chemical reactions concepts.	To gain insight of sense-making in the work completed by learners.
6	Stimulated recall interviews while watching the video together with learners.	Member checking.	To gain in-depth understanding of meaning-making and to seek clarifications.
Phase two	**Methods used to gather data**	**Data gathered**	**Purpose**
Stage 7	Development of unit of work.	Improving the teaching of chemical reactions.	Addressing misconceptions learners find challenging.

The following paragraphs discuss the data gathering techniques in detail.

3.5.1 Lesson presentation

The researcher initially planned to be an observer while the participant researcher Mrs Lolo (pseudonym) presented the lessons on chemical reactions. The teacher had a change of mind and asked the researcher to present the lessons while she videotaped them. She cited that as a Life Sciences teacher, she found the integration of prior everyday knowledge and presenting parallel lessons difficult. Therefore, we opted for the researcher to present the lessons while the participant researcher videotaped the lessons. This was not problematic as the focus of this study was on how learners make sense of concepts on chemical equations.

Merriam (2009) proposes that the researcher begins by presenting two lessons to become familiar with the context, the learners and the activities. These were followed by three intense and targeted lesson presentations (ibid.). Parallel lessons were presented. The lesson on using familiar resources was presented concurrently with conventional chemicals. The following are brief descriptions of the lessons presented.

Lesson 1: Oxidation of iron and magnesium

The lesson was 45 minutes long. Learners were randomly divided into six groups of six learners each. Each group was given two mathematical sets casings to compare. One had rust (heavily oxidised) and the other set was still new (free from rust). The investigation of nail rusting is covered in Grade 5 (Intermediate phase CAPS document) and the time taken for rust formation is at least 3 weeks. The time factor for rusting to occur was the reason that the activity was not carried out during the study and why heavily oxidised mathematical set casings were used as familiar resources.

Learners were asked to observe the two sets and to discuss their views on the differences in their groups. The interactive environment was characterised by dialogue between the teacher and learners and as well as learner-to-learner interactions. Well sequenced questions on the rusting process and its consequences were posed to engage the learners as they observed everyday chemical reactions on the resource (oxidised mathematical set casings). The purpose of the activity was to show learners a chemical change of iron into iron oxide using familiar material.

The next step focused on specialist chemical change, using conventional chemicals. Learners had to burn magnesium ribbon in groups. Each group was given two pieces of magnesium ribbon hanging on pegs to burn on the candle flame. They were required to make a prediction and state their predictions on the worksheet. The awesome brilliant light of first burning drew everyone’s attention. It increased learner engagement as each group waited eagerly for burning to happen.

Disappointment was observed as some ribbons did not catch fire. Discussions followed as to why some did not burn. Ribbons had to be scratched with sand paper to remove the layer of magnesium oxide that was preventing ignition of the magnesium ribbon. The magnesium finally burnt. The concept of metal oxides was discussed as a follow-up to magnesium burning. Learners seemed to enjoy this activity very much, especially the brilliant light (that resembles fireworks) produced by burning magnesium. After burning magnesium, the lesson was discussed with the learners. The purpose of the activity was for the learners to observe a chemical change of magnesium to magnesium oxide using conventional chemicals.

In both activities, visualisation was provided and the use of 'hands-on' 'words-on' and 'minds-on' practical activities engaged the learners. Thereafter earners were given worksheets to complete.

Lesson 2 (45 min): Reaction of egg in vinegar and of calcium carbonate in hydrochloric acid

The next lesson focused on chemical reactions involving substances in acids. Learners were asked to make their predictions of the reaction of an egg in vinegar. Thereafter, learners placed an egg in vinegar and left it for 50 hours. The experiment was left over the weekend and observations were done the following Monday. Still in their groups, learners were asked to note and share their observations as a class. The researcher did not anticipate observations like 'blood vessels' which were quite visible in some groups and the egg getting bigger. The purpose of the activity was for learners to observe everyday chemical reactions using familiar resources, vinegar and eggshells. Learners recorded their observations which included shells disintegrating in vinegar and the formation of bubbles. From their reactions, it was clear that learners were surprised by the outcome of the reactions as most learners had predicted that the egg would be 'cooked'. All groups recorded bubble formation as an observable phenomenon.

Since eggshells consist of about 98% calcium carbonate, a parallel lesson on the reaction between calcium carbonate and hydrochloric acid was given. Calcium carbonate and hydrochloric acid are examples of conventional chemicals. The groups of learners dropped a few drops of hydrochloric acid into powdered carbonate. They shared observations and completed worksheets with questions on egg and vinegar, and calcium carbonate and hydrochloric acid reactions.

Lesson 3 (45 min): Making lemon tea and blowing with a straw through clear limewater

The researcher brought prepared black tea because of time constraints and poured 100cm^3 of black tea into two 250cm^3 beakers and gave it to each group. Each group was asked to add 50cm^3 of lemon juice to one of the beakers containing the black tea. Learners were asked to compare the colour change of tea in the two beakers and were asked to share observations in order to learn from one another.

After the activity, learners were each given a plastic drinking straw and a test tube with limewater. They were asked to make predictions of what they would observe after blowing through limewater. After bubbling through limewater, learners observed colour changes and they discussed observations. They made drawings to show what was observed. Learners were given the opportunity to socially construct meaning during class discussions by asking them questions on observations and probing them further to provide explanations for their answers. Follow-up questions were asked to seek clarity on ambiguous responses and learners were asked to complete worksheets.

A video-recorder was used by Mrs Lolo to record the phenomena under investigation.

The final writing activity was the summative test (Appendix J) written in the next quarter, the fourth term, as learners were writing mid-year examinations. After the summative test, the researcher resumed data analysis of learners' worksheets.

3.5.2 Document analysis

Documents can be the main source of data for a research study (Merriam, 2009). In this study, learners' diagnostic tests, worksheets completed during the intervention process, learners' reflections, mind maps and summative tests were used. Purposeful sampling was done to select an illustration of documents from learner's responses. These provided insights into the prior everyday knowledge learners bring to the classroom as well as their misconceptions. The data was used to address concepts learners found challenging and to assist in scaffolding them during the lessons. The application of language by learners was noted and challenges addressed.

Direct quotes were constructed from documents which were used for data analysis. The data was scrutinised noting how learners construct meaning from the concepts taught. Having accrued learners' responses from diagnostic test, worksheets and summative test, interviews were conducted with the focus group as a follow-up to their responses in the worksheets. The learners' work was used to supplement interviews.

3.5.3 Interviews

An interview is defined as "a dialogue between the researcher and the research participant on a subject based on the study" (De Marrais, p. 55). In the study the researcher carried out semi-structured interviews with a focus group and stimulated recall interviews (SRI). Miller, Blessing and Schwartz (2006) echo the value of the use of interviews. They argue that interviews provide a deeper understanding of specific aspects under investigation. Although interviews have their drawbacks, such as being dominated by a few in the case of face-to-face interviews, sometimes they are the only way to get data (De Marrais, 2004). There are different forms of interviews.

3.5.3.1 Semi-structured interviews

The use of semi-structured interviews was used to uncover how learners made sense of chemical reactions during lessons involving familiar resources. Semi-structured interviews according to De Marrais (2004) are essential when it is difficult to perceive attitudes such as behaviour, motives, feelings, intentions or how people interpret the world around them. Most qualitative studies employ semi-structured interviews (Merriam, 2009). They were used in the research as they afforded an opportunity to probe the participants' responses, ask for clarification and follow-up questions.

Probing questions were used to ensure the questions were answered as fully as possible. The interview schedule (Appendix L) had six open-ended questions which directed the interviewing process on the six learners who constituted the focus group. The interviews were face-to-face and were videotaped by another teacher at the school who is a master's student. A pilot test of the interview questions was conducted with some learners. This assisted the researcher to restructure the questions after they were discovered to be colloquial. As a result of the pilot, the researcher had to increase the number of questions to ensure that all the research aspects were covered during the interviews. The use of focus group interviews using semi-structured questions was another vital strategy for data gathering as discussed below.

3.5.3.2 Focus group interviews

A focus group interview is described as an interview on a topic with a group of people who have knowledge of the topic (Krueger, 2008; Stewart, Shamdasani & Rook, 2006). Merriam (2009) regards it as a method of qualitative research where data collected is socially constructed within the interaction of the group. The focus group interview was conducted after administering the diagnostic and summative tests. Some of the open-ended questions required learners to elaborate on the reasons for their responses in the diagnostic test. Other questions directly addressed the research questions. The proceedings were videotaped. The role of the researcher was to facilitate the dialogue and to try as much as possible to elicit in-depth responses from the learners. A tablet was used to record the proceedings which later provided the basis for the stimulated recall interviews.

On two instances, the tablet indicated that its memory was full. This resulted in having to stop the interview to delete some content on the device. At each juncture before resuming the interview, the researcher recapped the topic before continuing.

3.5.3.3 Stimulated recall interviews

A stimulated recall interview is described as “an introspection procedure in which videotaped passages of behaviour are replayed to individuals to stimulate recall of their concurrent cognitive activity” (Lyle, 2003, p. 861). The rationale of this interview was to gain an in-depth understanding of how learners make sense of chemical reactions and to utilise the opportunity to provide clarity on the concepts. The videotape was shown to the focus group and questions requiring clarification were discussed. Raw data was critically analysed and clarifications sought for emerging points. The procedure was quite useful in the research process as the researcher managed to fill in gaps existing in the data.

3.6 Data analysis

The data sets consisted of transcribed interviews, a diagnostic test, learners’ worksheets (Appendix H), learners’ reflections, mind maps and a summative test. Merriam (2009) describes data analysis as the procedure followed in answering the research questions. The data was organised to ensure easy accessibility and interpretations. In this study, inductive analysis was applied (ibid.). This process began by labelling data sources. Texts were read through and the important texts underlined. Codes were used on response items. Coding is described as the process of organising data by identifying texts and writing words representing a category (Rallis & Rossman, 2012). The texts were read a second time looking at marked text and decisions were made about what category to assign it to. Emerging categories were listed on a sheet of paper and were checked in relation to the research questions. Analytical memos were drawn up whereby all data that fitted each category was organised into one place. Finally, an analytical memo was designed and all data categorised as reflected in Appendix (I).

Cohen et al. (2011) concur that qualitative data analysis is the interpretation of organised data for meaning-making. The data was then categorised into themes. The recurring themes and critical points were then interpreted and discussed. To validate the data, the following process was employed.

3.7 Validity

Validity is described as the degree to which an account accurately represents the social phenomena to which it refers (Silverman, 2010). The researcher had to carry out member validation. This is defined by Boeijie (2010) as the act of giving participants in a research study a chance to review and comment on the findings. In this study, follow-up interviews as well as stimulated recall interviews of videotaped lessons were conducted with the research participants to correct any misinterpretations. Member checking, by re-running the videotaped recorder with participants, was done to check that the researcher had not misrepresented them.

Combining the findings from the interviews, worksheet responses and test responses was another method used to improve validity. This is termed triangulation of data which Creswell (2014) describes as collecting data from different sources and examining evidence from the sources to build a coherent justification for themes. In support of this Lincoln and Guba (1985) note that validity is strengthened by an audit trail of evidence.

It is important to critically reflect on the influence of personal expectations and prejudices as the researcher was investigating one case study. Participation by the participant researcher played a role in establishing trustworthiness. The participant researcher assisted the researcher with videotaping lessons and the discussions of the interpretations.

3.8 Ethical considerations

According to Creswell (2014), consent is a priority in getting access to the participants and the research site. In this study, written consent was sought from the principal of the school involved (Appendix A); also, from the teacher participating in the research process (Appendix B). The consent letters are part of the appendices. Informed consent letters were signed by parents of the learners participating in the research since most learners were still minors (Appendix C). They were given to learners by the deputy principal of the school and assurance was given that all the information would be treated with confidentiality. This included the identity of participants and the data generated.

The forms were in line with the dictates that call for the protection of human rights (Creswell, 2014). In agreement, Terre Blanche et al. (2006) point out that the essential purpose of research ethics is to protect the research participants.

The aim of the study was explained to all participants and pseudonyms were used for the school as well as for the teacher participant. Participants were informed that withdrawal at any point was allowed with no prejudice to them. During the research process, some learners were absent in one lesson and present in the next. There was no consistency in terms of attendance. As a result, the average attendance per lesson was 32 learners.

3.9 Limitations of the study

Due to the small sample size and case study design, the findings of this study cannot be generalised. However, useful insights can be gained into how learners' make sense of chemical reactions using familiar resources; as one of the strengths of a case study is that it depicts reality. It is recognised also that the use of recording devices such as a video camera might alter the behaviour of teachers and learners. However, the impact was minimised by prior exposure of the device to the learners before actual recording.

3.10 Concluding remarks

In this chapter, the researcher described the paradigm underpinning this study as well as the methodological orientation, namely, a mixed methods approach. The research questions were outlined and the research site described. Sampling procedures and data gathering techniques such as the analysis of a diagnostic test, learners' worksheets, a summative test and interviews were also discussed.

The analysis of data and validation as well as ethical issues were described and the researcher concluded by giving a summary of the limitations of the study. The next chapter presents data gathered using a variety of techniques.

CHAPTER 4: DATA PRESENTATION AND ANALYSIS

4.1 Introduction

The goal of this study was to investigate how Grade 8 learners make sense of chemical reactions when using familiar resources. The study was conducted with the view of improving the mediation of learning. An interpretative paradigm was used together with a constructivist framework to study how Natural Sciences learners make sense of chemical reactions during lessons involving familiar resources.

This chapter presents the findings from the data collection process used in this study, namely, learners' worksheets, observations and semi-structured interviews with a focus group. Quantitative and qualitative results are presented. The quantitative results were derived from the diagnostic test, worksheet exercises from the intervention done and from the summative test. The qualitative data was derived from meanings, descriptions of the subject matter and observations.

This chapter commences with an outline of the process of administration and thereafter, data from each technique is presented.

4.2 Diagnostic test

A diagnostic test (Appendix F) was administered to elicit the extent of learners' prior knowledge. The questions were drawn from three sources namely; CAPS documents, textbooks aligned to the curriculum and readings related to chemical reactions.

A pilot test was undertaken with 15 learners whose characteristics were reflective of those in the focus group. This helped to improve the wording, and ambiguous and irrelevant sentence structures were eliminated. Diagrams were added to some abstract questions and neutral options were eliminated together with some questions which asked learners' general opinions. The pilot test contributed to contextualising the diagnostic test by making it learner friendly.

Sequencing of questions

Questions were set on everyday examples of chemical and physical changes. For each question, learners were required to justify their choice of responses by giving explanations. This was done in order to find out which of the concepts related to chemical reactions learners found challenging and to unearth the misconceptions they brought to the science classroom. Questions on specialist examples of chemical and physical changes were also posed.

The main research question is: How do Grade 8 learners make sense of chemical reactions using familiar resources? It was imperative that activities in the lesson plans were designed to check the impact of familiar resources and conventional chemicals by presenting parallel lessons using familiar resources to learners and conventional chemicals from the laboratory. The diagnostic test was administered to 32 Grade 8 learners.

Quantitative data is presented in the form of tables and bar graphs for easy interpretation and qualitative results were used to collaborate the data. Both sets of data corroborate on the same research questions. The following table and graph shows the summary analysis of the diagnostic test.

Table 4.1: Diagnostic Test Results

Grouping	**Everyday example of chemical change**				**Specialist example of chemical change**		**Everyday example of physical change-boiling**		**Specialist example of physical change**			**Everyday example of physical and chemical change**		**Atomic Structure.**	**Elements and Compounds**
Question No.	1	2	8	12	14	15	3	4	5	11	13	9	10	6	7
Correct	41 %	25 %	44 %	56 %	34 %	31 %	44 %	31 %	22 %	34 %	41 %	25 %	19 %	56%	53%
Incorrect	59 %	75 %	56 %	44 %	56 %	69 %	56 %	69 %	78 %	66 %	59 %	75 %	81 %	44%	47%
Percentage	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

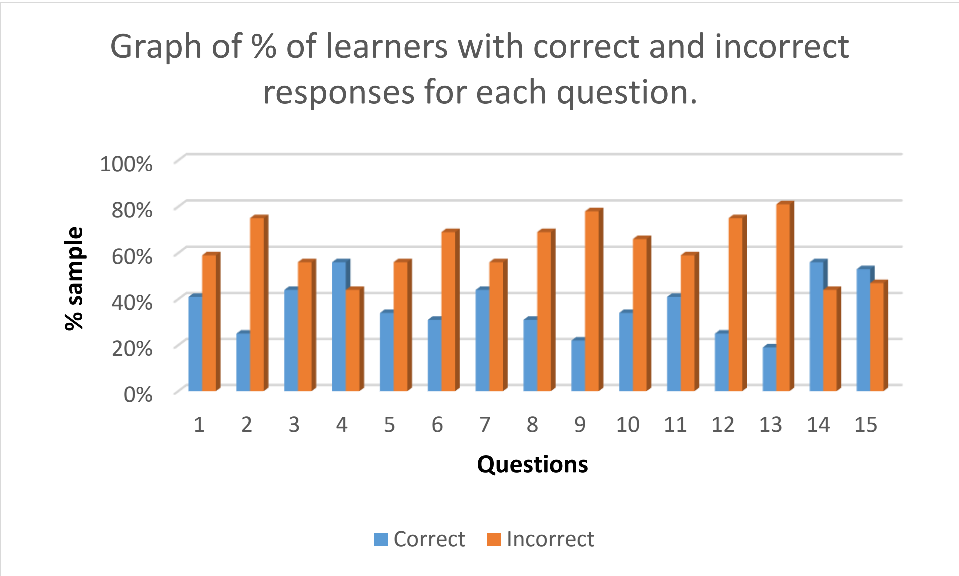

Figure 4.1 : Diagnostics Test Results

Data is presented thematically and the themes were intentionally drawn from learners' set questions which are in line with the research sub-questions. The results show two broad themes, namely, everyday chemical change versus specialist chemical change and everyday physical change and specialist physical change. The relationship of the questions to the research questions led to the grouping as listed in Table 4.1 above.

Most learners could answer questions on atomic structure, elements and compounds 'fairly' well. From the results of atomic structure, elements and compounds, it was assumed learners generally understood the basic concepts required for a conceptual understanding of chemical reactions; hence the intervention excluded such concepts. From the outset, learners found the meaning of scientific concepts related to physical and chemical changes, change of state, expansion and contraction, and oxidation of metals in chemical reactions difficult to construct precise meanings for. The concepts of burning, boiling and heating potentially interfered with comprehension of concepts related to the interpreting of chemical reactions.

In an attempt to explain why the level of boiling water in the beaker decreased during heating, some learners wrote the following excerpts as their explanations:

Learner: It's because heat is the destroyer of particles… (Appendix M Diag: MS-1p2). Another learner wrote the following as an explanation for the melting of wax when warmed:

Learner: It's a physical change because when you light it goes down bit by bit (Appendix M Diag: NS-4p4)

On the reason for expansion and contraction of materials the learner wrote the following excerpt:

Learner: Iron ball shrinks when it gets cooled down (Appendix M Pilo: NS-5p1)

On whether the mass of a nail left outside for a long time to rust increases or decreases when weighed on a scale, one learner wrote the following excerpt:

Learner: Mass of nail decreases because the particles are broken down (Appendix M Diag: MQ-1p1).

The above explanations, which are direct verbatim quotations, suggest that learners were operating in everyday contexts and that they link physical and chemical phenomenon to observable changes. Consequently, the researcher decided to undertake an intervention in the form of taught lessons. Three lessons were structured in such a way that everyday chemical reactions and specialist chemical reactions, using conventional chemicals were taught concurrently (Appendices G-I). The part of the lessons on everyday chemical reactions was presented using resources familiar to learners and specialist chemical reactions in the parallel lessons using conventional chemicals.

4.3 Lesson presentation

In each lesson, two practical activities were given, one on everyday chemical change and the other on specialist chemical change using conventional chemicals. In both cases, learners were given an opportunity to engage in both practical activities, one after the other, and answer questions related to the work done on worksheets. The results from the exercises addressed the research question: *Which concepts related to chemical reactions do Grade 8 Natural Sciences learners find difficult?*

The following table and graph shows an analysis of the worksheets results of the lesson on oxidation of magnesium.

Table 4.2: Results of iron and magnesium oxidation

	Everyday chemical change				**Specialist chemical change**				
Questions	1. Defining rusting.	2. Why rusting is not a useful reaction?	3 How to protect things from rusting.	4 Factors that cause rusting.	5. Make prediction if you place magnesium on flame.	6. Naming of reactants of magnesium burning.	7. Naming of products of magnesium burning.	8. Explanation of changes of magnesium burning.	9. Products and reactants in reactions.
Correct	51%	29%	36%	86%	65%	58%	44%	44%	42%
Incorrect	49%	71%	64%	14%	35%	42%	64%	56%	58%
Percentage	100	100	100	100	100	100	100	100	100

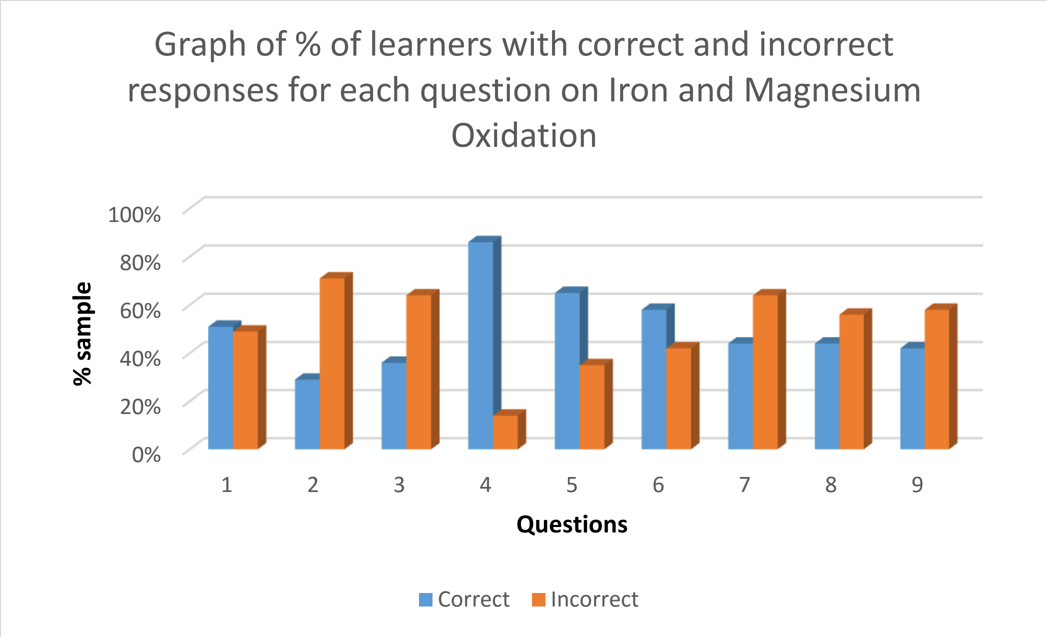

Figure 4.2: Results of Iron and Magnesium Oxidation

The results showed that most learners seemed to understand the explanation and factors affecting the rusting process when everyday chemical resources are used. This is shown by the high percentage (86%) being obtained using everyday chemical resources and a considerably lower result of 44% of the learners who could explain the change that takes place when the magnesium ribbon burned in the air.

The factors that cause rusting were stated well and the results on the bar graph showed the highest percentage of correct responses on that item. Most learners mentioned the presence of oxygen and water in the rusting process. However, some learners were not precise in their definitions as they made sense of rusting as shown by excerpts from the worksheets below:

Learner: Rusting is when a substance such as water and oxygen gets attracted to an iron or steel (Appendix N Wrk1: MS-2)

Learner: Rusting is a chemical reaction which contains water and oxygen (Appendix N Wrk: ML-3).

Other learners wrote the following responses:

Learner: Rusting is when something becomes dull with brownish colour (Appendix N Wrk1: MQ-1)

Learner: Rust is something that is old (Appendix N Wrk 1: MM-1).

Limitations of learners' vocabulary seemed to hinder meaning-making in the above descriptions of rusting. The implications of this are discussed further in the next chapter.

The following table and graph shows results from learner worksheets of the lesson on egg/vinegar and calcium carbonate/hydrochloric acid reactions:

Table 4.3: Results of the exercise on egg/vinegar and calcium carbonate/hydrochloric acid reactions

Grouping	Everyday example of chemical change.				Specialist chemical change.			
Questions	1a- Observations- egg in vinegar	1b– Reactants of egg/vinegar reaction.	1c– Reasons for egg breakdown in vinegar?	1d– Products in $CaCO_3$/HCl reaction	2a– Observations in $CaCO_3$/HCl reaction	2b- Naming reactants in $CaCO_3$/HCl reaction	2c- Naming Products in $CaCO_3$/HCl reaction	2d- Signs showing reaction.
Correct	56%	100%	71%	76%	56%	81%	69%	74%
Incorrect	44%	0%	29%	24%	44%	19%	31%	26%
Percentage	100	100	100	100	100	100	100	100

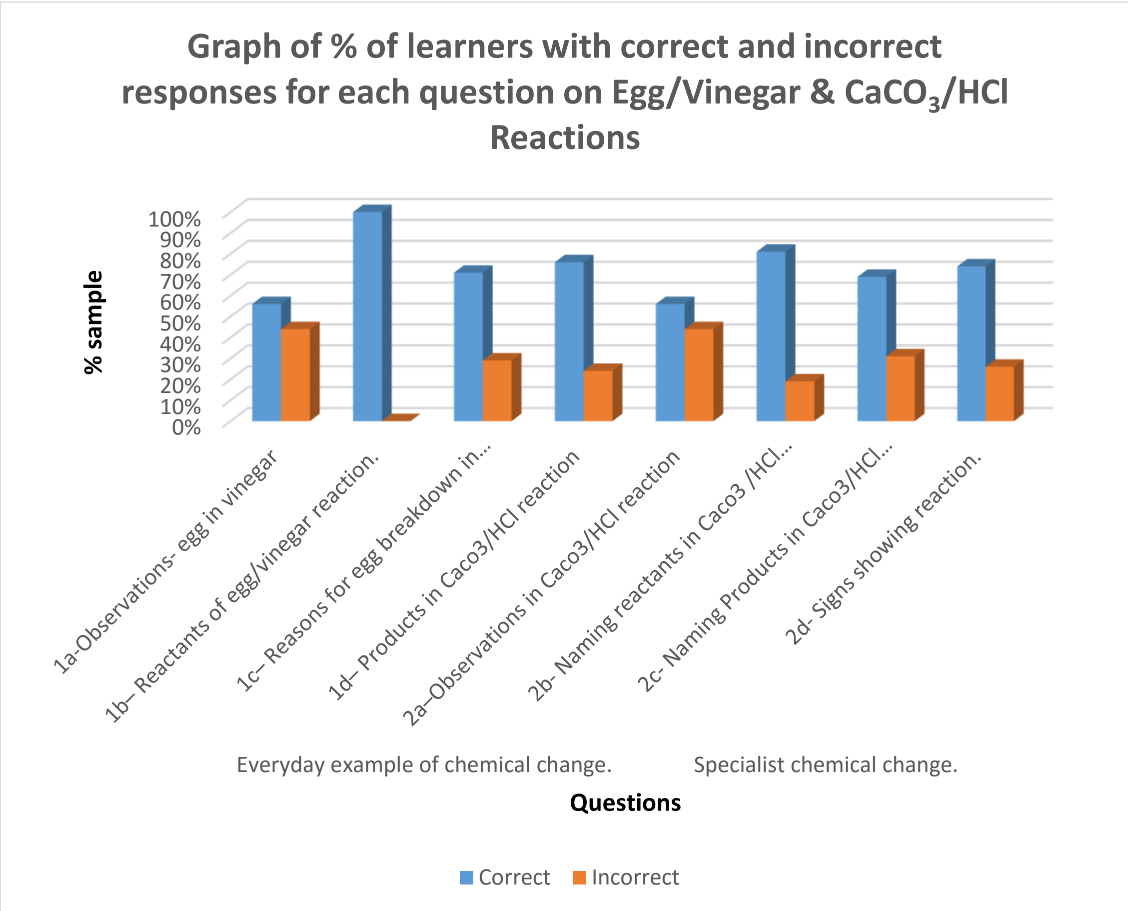

Figure 4.3: Results of the Egg/Vinegar & $CaCO_3$/HCl Reactions

The results showed that most learners understood the concepts taught when both everyday examples of chemical substances and conventional chemicals were used. However, what became significant about learners' responses was they all stated the reactants of the egg and vinegar reaction. The percentage was substantially higher (100%) than when conventional chemicals were used (76%). Nonetheless, the fact that some of the learners could answer questions using specialist chemicals well was of relevance to this study. It was assumed that learners seemed to learn better when engaged in practical activities.

From the learners' worksheets, the following observations were made. Referring to the reaction of the egg in vinegar, some learners wrote the following excerpts:

Learners: It starts to boil (Appendix O Wrk2: MB-2; MA-4; NA-3).

Others wrote the following excerpt as observations:

Learners: *Egg getting bigger; egg breaks down (Appendix O Wrk2: ML-5; Appendix O Wrk2: MA-2)*

Precise scientific meaning was absent in the learners' responses of reaction. Interpretations of the excerpts are given in the next chapter.

The last lesson focused on how learners made sense of some observable phenomenon. The phenomenon investigated was colour change. Learners were to determine some characteristics that could be used as evidence of a chemical change happening.

The following table and graph show results obtained from learner worksheets from the lesson.

Table 4.4: Results of making lemon tea and of bubbling of carbon dioxide into limewater

Grouping	**Specialist chemical change**			**Everyday chemical change**		**Everyday and specialist chemical changes**		
Questions	**1. i Observations.**	**1. ii Explanation of observations.**	**1.iii Naming of reactants**	**2. i Explanations.**	**2. ii Observations.**	**2. iii Indicators**	**2. iv Definition of an indicator.**	**2. v Chemical reaction and support reasons.**
Correct	94%	43%	91%	64%	97%	47%	17%	63%

Incorrect	6%	57%	9%	36%	3%	53%	83%	37%
Percentage	100	100	100	100	100	100	100	100

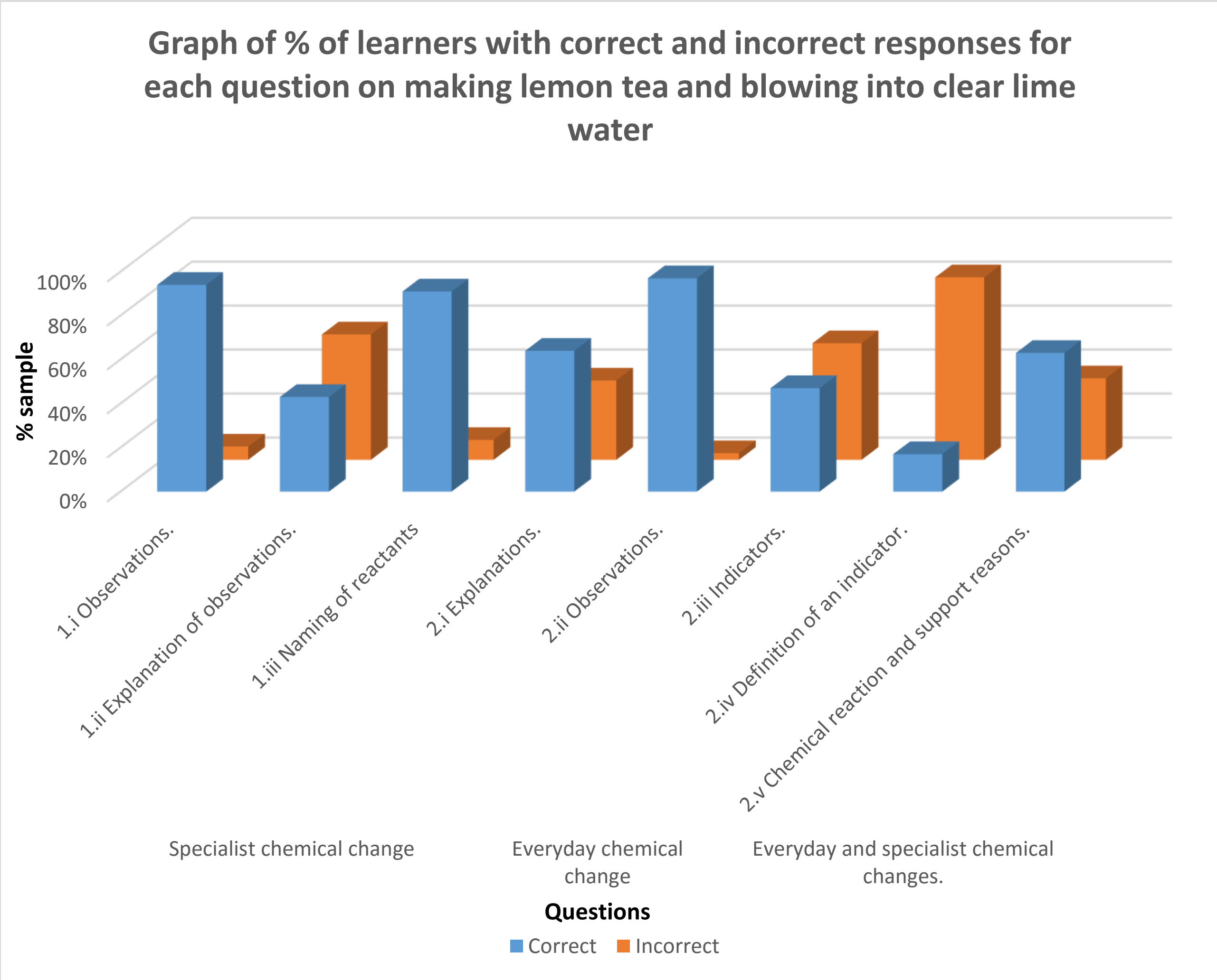

Figure 4.4: Results of making lemon tea and of bubbling of carbon dioxide into limewater

The results showed that most learners could not answer questions on the 'indicator'. However, more than half of the learners wrote correctly:

Learner: Black tea is the indicator (Appendix O Wrk3: MA-1; MP-1: MN-1 etcetera).

The topic on indicators was covered in Grade 7, term 2, under the topic acids and bases. Red and blue litmus papers are mentioned in the CAPS document for senior phase (p. 24) as examples of indicators. Learners seemed to lack prior knowledge related to indicators in this regard. The results also showed learners answering questions on observations well when conventional chemicals were used, but the majority could not explain their observations clearly.

The results addressed the following research question: *Which concepts related to chemical reactions do Grade 8 Natural Sciences learners find difficult?*

The summative test was administered in the fourth term. The research process involving learners could not resume because of mid-year examinations**.** The vacation was a short break of about a week. After 15 days, the summative test was administered.

4.4 Summative test

A summative test (Appendix J) was administered to respond to the main research question: *How do Grade 8 learners make sense of chemical reactions during lessons using familiar resources?* The summative test assessed the effect of the unit of work and completed worksheets on sense-making of the learners. Learners' free responses to questions showed how they constructed meaning and implications on sense-making. This helped to answer the main research question. Below are the results of the summative test.

Table 4.5: Results of the Summative Test

Themes	**A**: Everyday CC: **rusting**			Specialised CC**: Mg burning**			**B**: Everyday CC: **egg + vinegar**		Specialised CC: **HCl + $Caco_3$**		**C**: Everyday CC: **Tea making**		Specialised CC: Ca**$C0_3$ + limewater**		
Questions	1.1.1	1.1.2	1.1.3	1.7.1	1.7.2	1.7.3	1.5.1	1.5.2	10.1	10.2	1.8.1	1.8.2	1.4.1	1.4.2	1.4.3
Correct	14%	50%	53%	22%	9%	20%	69%	54%	31%	11%	78%	57%	28%	15%	34%
Incorrect	86%	50%	47%	78%	91%	80%	31%	46%	69%	89%	22%	73%	72%	85%	66%
%	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

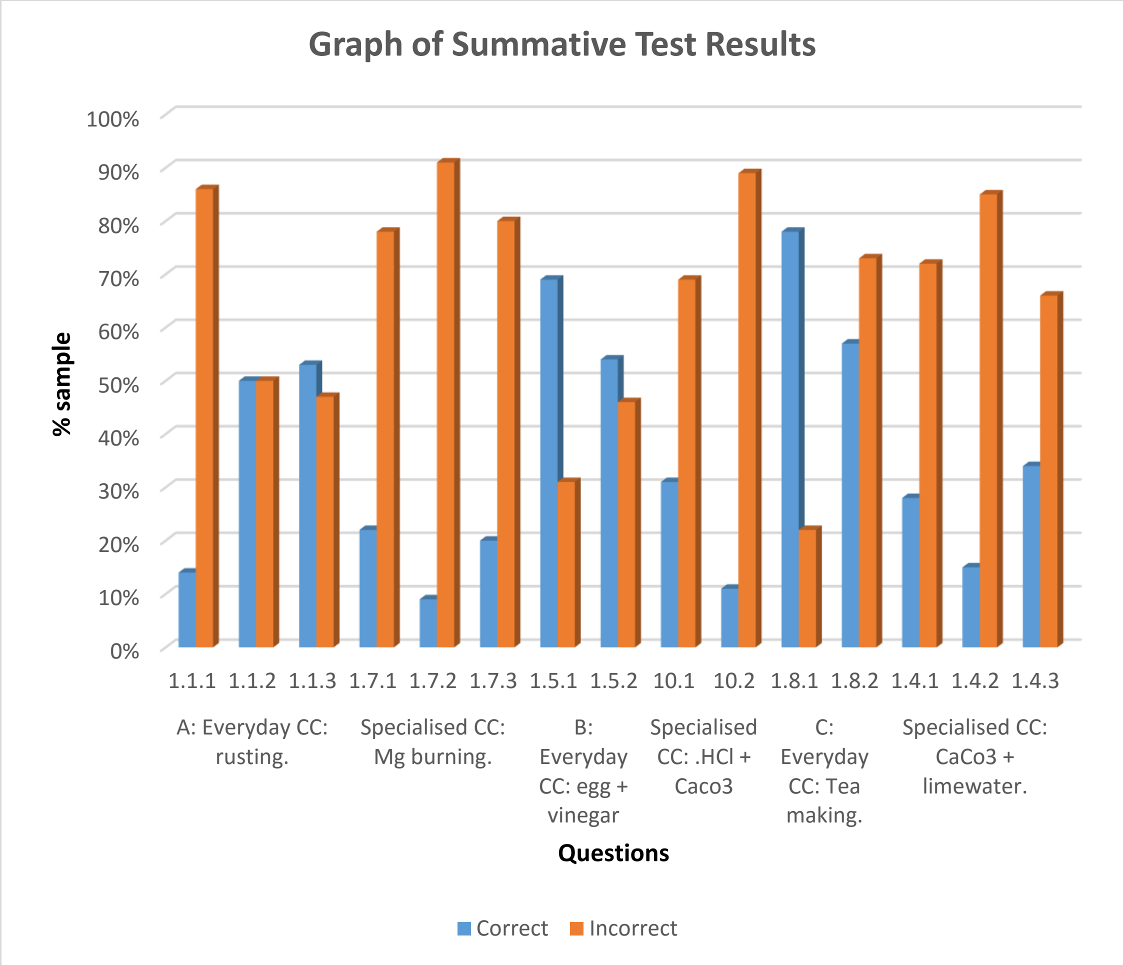

Figure 4.5 : **Summative Test Results**

(a) The results show a comparison of two reactions, oxidation of iron and oxidation of magnesium. The table shows that learners could answer questions on oxidation of iron better compared with the questions on oxidation of magnesium. The learners identified rusting as a chemical change process. Heavily oxidised mathematical set casings brought to the classroom as examples of rusted materials assisted learners to respond well to questions. In spite of this, few learners (14%) could correctly define the term 'rusting'.

(b) The results show that learners answered questions on the reaction between egg shells and vinegar better than those on hydrochloric acid (HCl) and calcium carbonate ($CaCO_3$). More learners made accurate observations of the chemical reaction of the egg in vinegar.

(c) The adding of lemon juice to black tea and blowing of carbon dioxide in limewater showed colour changes as evidence that a chemical reaction had occurred. The results showed that most learners understood the chemical change in tea making better than the change resulting from blowing with a drinking straw through clear limewater. Many learners could describe colour change of black tea when lemon is added. Furthermore, 57% of the learners correctly stated that the reaction of black tea and lemon juice is a chemical reaction. The results suggest that learners related well to everyday chemical change concepts.

Table 4.6: Summative results of physical changes; Atomic structure; Compounds and elements and bonding

Themes	D: Physical changes-ice melting		Physical changes-boiling water				E: Atomic structure		F: Compounds and elements		G:Bonding		
Questions	1.2.1	1.2.2	1.3.1	1.3.2	1.3.3	1.3.4	1.9.4	11.2	11.3	11.4	1.9.3	1.9.5	11.1
Correct	34%	11%	31%	6%	3%	53%	22%	41%	34%	28%	19%	22%	41%
Incorrect	66%	89%	69%	94%	97%	47%	78%	59%	66%	72%	81%	78%	59%
Percentage	100	100	100	100	100	100	100	100	100	100	100	100	100

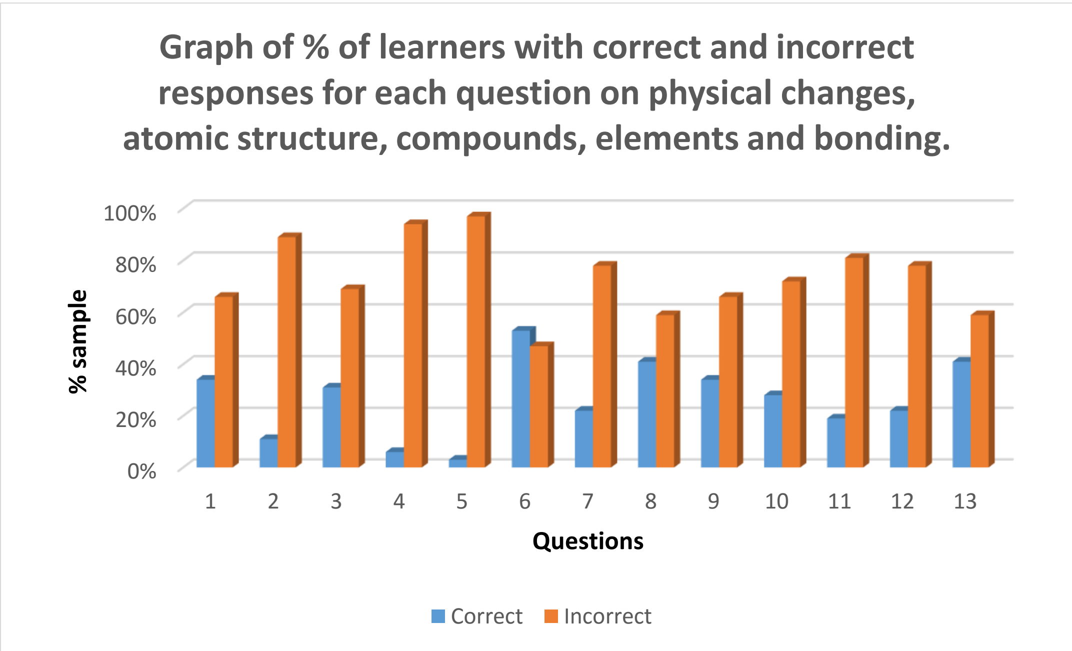

Figure 4.6 : Summative results of physical changes; Atomic structure; Compounds and elements and bonding

(d) The majority of the learners could not answer questions on physical and chemical changes. Some learners (53%) could state that water vapour is in the clear bubbles of boiling water. Questions linked to concepts leading to understanding of chemical reactions were not answered well. Although, learners performed well to questions in the diagnostic test, results of the summative test proved otherwise. These questions included concepts on the atomic structure, elements and compounds. The topics were taught before the research process. This may suggest a content gap on the part of the learners.

Table 4.7: Summary of summative test of everyday examples of chemical change

Themes	Everyday: **teeth cleaning**.		Everyday: **decaying**	Everyday: **ripening**	Everyday: **cooking**	I: Particle model of matter	J:Chemical reactions: signs.		
Questions	1.6.1	1.6.2	12.2	12.5	12.4	12.3	13.1	13.2	13.3
Correct	34%	9%	19%	19%	47%	53%	38%	22%	22%
Incorrect	66%	91%	81%	81%	53%	47%	62%	78%	78%
Percentage	100	100	100	100	100	100	100	100	100

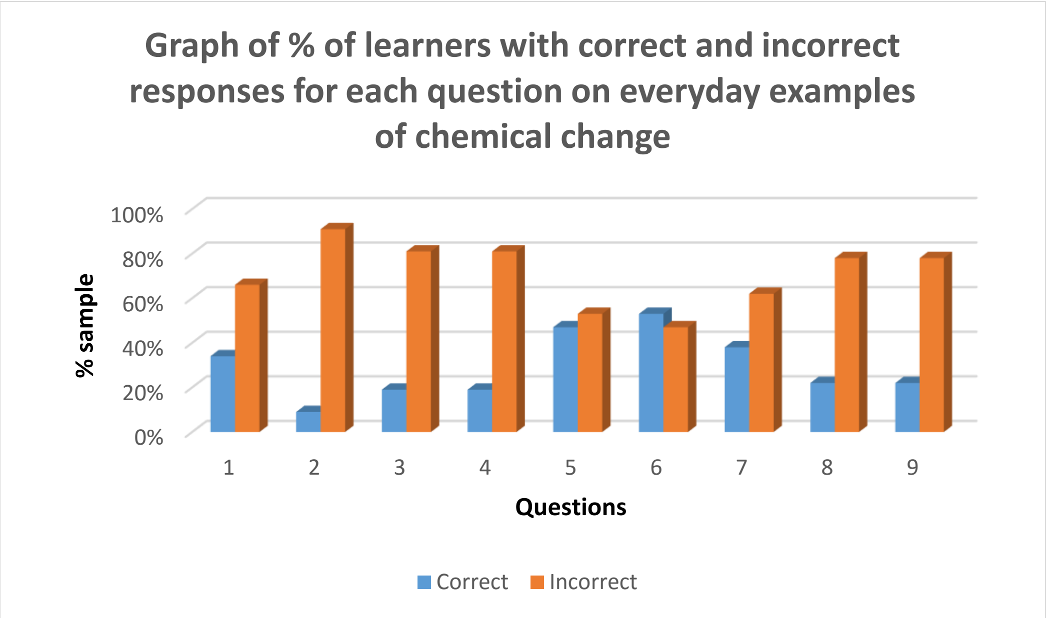

Figure 4.7: Summary of summative test of everyday examples of chemical change

(e) Selected questions which required learners to identify if every day phenomena were chemical changes were not answered well. The topics were taught before the research process. This possibly explains why learners could not explicitly state all signs showing that a reaction was occurring.

Table 4 8: Summary of summative test results of products/reactants and expansion and contraction of materials

Themes	**K: Chemical reactants/products**		**L: Expansion and contraction**
Questions	1.9.1	1.9.2	11.5
Correct	19%	13%	41%
Incorrect	81%	87%	59%
Percentages	100	100	100

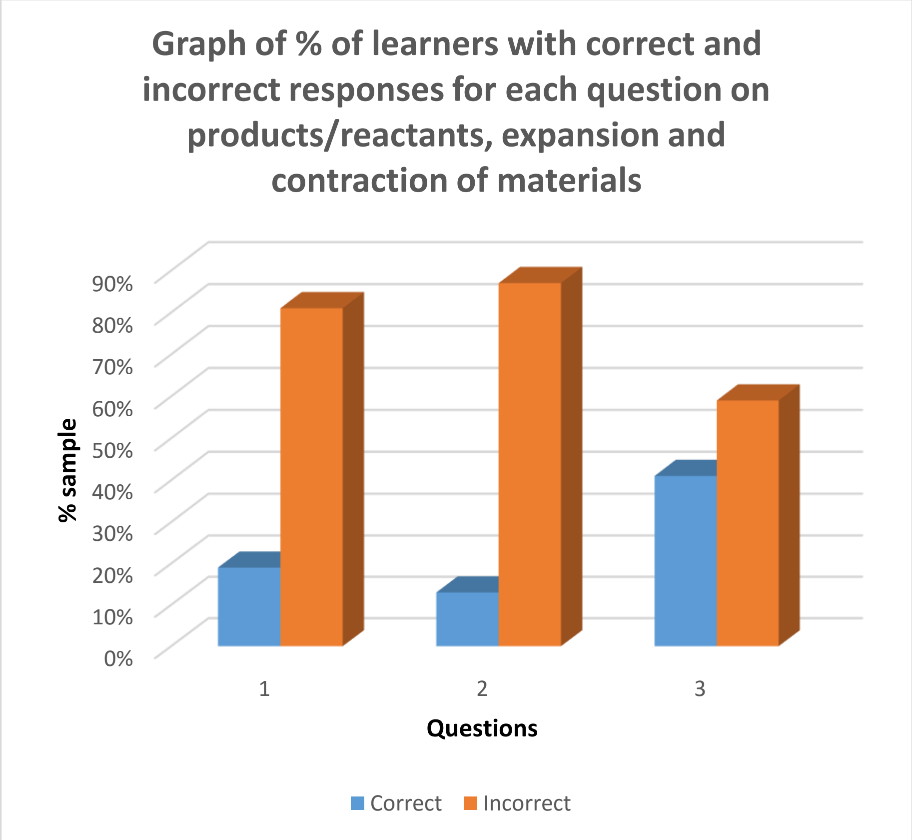

Figure 4.8: Summary of summative test results of products/reactants and expansion and contraction of materials

(f) Learners could not answer questions related to identification of products and reactants as well as questions linked to expansion and contraction of materials. The reason was possibly that they were no practical activities related to the teaching of the concepts.

4.5 Focus group interviews (45 minutes)

The focus group interviewees consisted of six learners who were purposively selected. In the diagnostic and summative tests the researcher came across responses related to the research questions. Six learners were selected to provide a follow-up on their given responses.

Consequently, the focus group comprised four girls and two boys. The learners were also comfortable conversing in the English language.

The interviews were conducted in the classroom arranged for the purpose. A teacher at the school, who is a fellow Master of Education student, videotaped the proceedings using a tablet. Fearing that the research process could be compromised, the participant researcher could not be used as she is the subject teacher.

As an ice-breaker, each learner was asked to share with the group their primary schooling experiences. Having observed that learners were relaxed, the researcher asked them why the topic on chemical reactions is regarded as difficult by some learners. Learner 1 (L1) who responded first said:

L1:"*The topic was new to them…" (Appendix L: L1).*

The researcher probed deeper about what the learner regarded as new and L2 said:

L2:"Some words need a dictionary to understand them" (Appendix L: L2)

When probed why it is difficult to follow the lesson, L5 said:

L5:"*Many scientific words teachers use, we don't understand them. The words are 'big', for example, hydrochloric acid, photosynthesis and many others". (Appendix L: L5).*

The entire group agreed with L5 remarks. Participants were asked what should be done and L3 remarked that:

L3: "*Teachers should mix English and Xhosa to help us understand as these 'rare' words are a challenge for us. We lose interest in the learning process because of these 'hard' terms" (Appendix L: L3).*

The researcher asked a follow up question (question 2) for learners to describe what they thought of learning chemical reactions. L6 pointed out that:

L6: "Teachers should use substances they see every day like the ones we were using. Substances we use at home to make learning of chemical reactions easier to understand" (Appendix L: L6

L1 echoed these sentiments:

L1:"I will be focused on unfamiliar substances because I fear that it will damage my skin and not focussing on the lesson" (Appendix L: L1).

Learners noted that the use of resources they were accustomed to be the best way of learning chemical reactions. The researcher did not specifically ask the question: Do you find the use of familiar resources a useful way to learn chemical reactions? The learners had discussed it as the question was covered during questions 2 and 3 discussions. However, the learners were probed to add more. L2 said:

L2:"Using what we know like eggs and vinegar made us discover what we did not know" (Appendix L: L2).

Like what? The researcher probed.

L2: "Like vinegar is an acid".

Teacher: What does an acid do?

L3:"It makes egg shell to dissolve (Appendix L).

L3 joined in the discussions.

On the last question which read: Do the learners find the use of practical activities in the learning of chemical reactions useful or not? The learners gave the following responses:

L4: "Practical activities make science easy as practical activities are easy to follow. I enjoy".

L1: "We see what we are doing and practical activities help us to develop more knowledge".

L6: "Easy to remember and help us to handle substances such as acids".

L3: "Practical activities link things we know with sciences in the classroom and makes science fun to do".

L5:"Practical activities help us to know substances that react and those that do not". (Appendix L)

The interview took longer than 45 minutes because of probing done to seek clarity.

4.6 Concluding remarks

In this chapter the researcher presented and described the data generated from the diagnostic test, learners' worksheets, summative test and focus group interview. Analysis of data from such documents revealed that learners' ability to precisely express scientific concepts is limited. Semi-structured interviews with the focus group revealed the challenges that learners face and described the best ways of learning about chemical reactions.

A number of factors influencing how learners make sense of chemical reactions using familiar resources were highlighted. In the next chapter, data in this chapter is further analysed and presented using analytical statements based on the data.

CHAPTER 5: INTERPRETATION AND DISCUSSION OF FINDINGS

5.1 Introduction

In Chapter 4, the researcher presented narratives constructed from the data captured using four data gathering techniques namely, a diagnostic test, learners' worksheets, a summative test and semi-structured interviews with a focus group. In this chapter data is interpreted and discussed with the intention of gaining a deeper insight into how learners make sense of chemical reactions when familiar resources are used.

Analytic memos (Appendix I) were constructed from the data gathered in which data was grouped into categories which were derived from the themes that emerged from the data. Furthermore, from the analytical memos, analytical statements were inductively developed in relation to the research questions guiding this study.

The discussion of the analytical statements is underpinned by literature, theory and personal view points. From the discussion, concluding remarks and recommendations regarding how learners make sense of chemical reactions when familiar resources are arrived at.

The following are the research questions that guided this study:

1) How do Grade 8 learners make use of prior everyday knowledge to construct their understanding of chemical reactions?
2) To what extent do practical activities involving familiar resources enhance or constrain the learning of chemical reactions in Grade 8 Natural Sciences lessons?
3) Which concepts related to chemical reactions do Grade 8 Natural Sciences learners find difficult?

This chapter attempts to make sense of the learners' responses, always being conscious of the patterns that emerged in order to gain a more comprehensible trend of what was investigated. In view of the research questions above, three analytical statements were developed for analysis as shown in Table 5.1 below:

Table 5.1: Analytical statements

Data source	Theme	Analytic statement	Research question(s) addressed
Learners' Worksheets, Pilot, Diagnostic Summative tests and Concept maps.	Everyday notions of oxidation of metals	Sense-making in relation to applying prior knowledge practices.	1
	Uses of everyday prior knowledge to explain scientific concepts.		
	Prior knowledge concepts culminating in chemical reactions understanding.		
	Atoms as building blocks of matter.		
	Responses linked to change of state.		
Learners' Worksheets, Summative test, Concepts maps and reflections.	Responses due to learner observations of practical activities.	Sense-making in relation to interpreting observations of practical activities	2
Pilot, Diagnostic and Summative tests; Reflections on Concepts maps and Focus group interview.	Learner descriptions of physical phenomena.	Concepts found challenging by learners and their responses after mediated activities by a teacher.	3
	Learners' description of chemical phenomena		
	Responses may indicating conceptual challenge in learners.		
	Responses indicating conceptual grasp of chemical reactions.		
	Responses linked to reactants and products.		
	Responses linked to the use of familiar resources.		

5.2 Analytical Statement 1: Sense-making in relation to applying prior knowledge practices (Appendix N)

The analytical statement 1 showed how sense-making was hindered by learners applying prior knowledge from concrete observed experiences to the abstract world of science. Everyday notions of oxidation of metals were discussed followed by uses of everyday prior knowledge to explain scientific concepts.

Everyday notions of oxidation of metals

Results from learners' worksheets about rusting indicate that their definitions and descriptions of iron rusting are not scientifically precise as shown by the excerpt below:

Learner: Rusting is when a substance such as water and oxygen gets ***attracted*** *to an iron or steel (Appendix N Wrk 1: MS-2).*

According to the constructivist learning theory which underpins this study, learners come to chemistry lessons having accrued misconceptions during their interaction with the world (Boo & Watson, 2000). Misconceptions can occur when learners arrive at school with an understanding of the meanings of everyday words that differs from the scientific meaning as highlighted earlier (Nakhleh, 1992). In the excerpt above, the word *'attracted'* is a commonly used word that has an everyday meaning different from its scientific meaning. As a result, the response indicates ambiguity of meaning because of the word *'attracted'* being placed in the definition. Although the learner highlighted the conditions for rusting to occur, namely, the presence of oxygen, water and iron or steel, meaning-making has been hindered by a semantic error.

Responses also show evidence of the use of perceptual thinking instead of conceptual thinking (Boo, 2002). The excerpt indicates that water and oxygen settle down on iron or steel for rusting to occur. The learner is using everyday notions about attraction, a physical phenomenon in magnetism. The learner is using reasoning that is more appropriate for physical changes to describe a phenomenon in chemical reactions.

Another learner wrote:

Learner: Rusting is when something becomes dull with brownish colour (Appendix N Wrk 1: MQ-1)

Learners do not often consider a chemical reaction as the complete transformation of matter itself, but as only change in appearance or a change in the state of matter (Eilks et al., 2007). This change in appearance, regarded as operating on phenomenological level by Eilks et al. (2007) is dominated by everyday perceptual clues (Boo, 2002). The learner is applying everyday knowledge without engaging precise scientific meaning. Learners have failed in their sense-making to focus on the metal exposed to oxidation elements, which is oxidised to give a product of a different colour.

Uses of everyday prior knowledge to explain scientific concepts

In their endeavour to describe the reaction of the egg and vinegar, learners wrote the following excerpts in their worksheets and concept maps:

Learner: It starts to boil (Appendix N Wrk 2: MB-2; MA-4; NA-3)

Learner: The egg is eaten up by vinegar until it is soft (Appendix N Cm: NL-1)

What emerges from the learners' response is interference of everyday language in meaning-making of scientific concepts as highlighted earlier. Learners lack the appropriate vocabulary to describe observable phenomenon in the reaction of vinegar and the egg. They use the term boiling frequently as it is used in everyday language. In addition, they are familiar with many common everyday experiences where the term 'boiling' is used.

Boiling, as well as *eaten* in the excerpts, is part of everyday life and learners' view of it is dominated by everyday perceptual clues, for example gas formation in boiling water (Boo, 2002). Again, learners are applying prior knowledge from observed concrete experiences to the abstract world of science. Hence, one of the first considerations by teachers when introducing new information to learners should be the establishment of the extent of the learners' prior knowledge (Meyer, 2004). Misconceptions that they arrive with should be addressed.

5.2.1 Prior knowledge concepts culminating in understanding of chemical reactions understanding (Appendix P)

The above statement considered some concepts learners should have prior to the introduction of chemical reactions. These concepts include the structure of the atom and changes of state. Responses linked to atoms as building blocks of matter were discussed as well as responses aligned to change of matter.

Atoms as building blocks of matter

Without a thoughtful consideration of the kinetic theory of matter, many topics in chemistry do not make conceptual sense and are learned by rote (Nakhleh, 1992). Some concepts are building blocks to understanding chemical reactions and failure on the part of the learner to assimilate them results in them not understanding chemical reactions. The following are some extracts from the learners:

Learner: All matter is made up of the smallest building blocks called mixtures, they are everywhere in the food we eat (Appendix P Diag: MN-2p2).

Learner: Atoms are everywhere in the food we eat, they got oxygen that comes from plants (Appendix P Diag: NL-1p3).

The researcher's first assumption that learners did understood the concepts on atomic structure and elements and compounds that culminate in understanding of chemical reactions, proved to be wrong. In Table 4.1, 56% correct responses were recorded on atomic structure and 53% on elements and compounds respectively during the diagnostic tests. The above percentages dropped significantly on the summative test (Table 4.6). The results indicate that learners memorised concepts from texts without real understanding (Eilks et al., 2007).

Responses linked to change of state of matter

Change of state is a concept taught in Grades 4, 6, 7 and Grade 8. Learners were asked to state whether given changes of state were chemical changes or not and to justify their responses. The following excerpts help to comprehend how learners make sense of chemical reactions in relation to changes of state:

Learner: Chemical change as wax has changed its form, to become water because it melts (Appendix P Diag: NL-1p4).

Learner: Chemical change because wax change to clear liquid (Appendix P Summ: MS-5).

Change of state, especially melting of ice to evaporation is a concept taught to learners so that they are able to differentiate between chemical and physical change. In the above excerpts, learners wrongly categorised physical phenomenon as chemical.

What emerged was that learners do not often consider chemical reactions as complete transformation of matter itself, but as only change in its appearance or a change in state; as highlighted earlier, (Eilks et al., 2007). Learners did not understand the difference between physical and chemical change. This hindered conceptual understanding of chemical reactions. The CAPS document for senior phase does not explicitly introduce the idea of physical and chemical changes in the early stages of chemistry instruction. The concepts are not stated as ideas that need to be targeted in teaching. Learners' difficulties with chemistry are symptomatic of a curriculum where important ideas are missing (Johnson, 2000). The content gap in the curriculum could be another reason to explain the learners' inadequate understanding of the concept of chemical reactions.

Boo (2002) suggests that a basic understanding that physical changes (for example, state changes) can co-exist with chemical changes is fundamental. This may assist to avert the common misconception shown by the two extracts above.

5.3 Analytical Statement 2:
Sense-making in relation to interpreting observations of practical activities (Appendix O)

This analytical statement showed how learners used practical activities to comprehend scientific concepts and how the activities that were carried out contributed to sense-making of observable phenomenon. The power of practical work is elaborated and justified below.

A considerable number of authors (Gott & Duggan, 1996; Tiberghien, 2000; Miller, 2004; Woodley, 2009) have considered the strength of practical work in school science. The authors have expounded on the power of practical work to help learners to acquire scientific knowledge for themselves and remember it better. In some classroom situations, practical activities are indispensable and irreplaceable (Miller, 2004).

Results from excerpts in Table 4.3, in Chapter 4, showed that learners stated correctly observable phenomena required. The excerpts are:

Learners: I have observed bubbles (Appendix O Wrk 2: MA-1; MK-1; etcetera)

The majority of the learners (56%) wrote this for questions 1(a) and 2(a) correctly. From Table 4.4, question 1(i), 94% of the learners wrote correctly: *Changing the colour* as observable phenomenon for the question. On question 2(ii) requiring observations for everyday chemical change, the percentage increased to 97%.

The above results indicated that engaging learners in practical tasks enhances conceptual understanding. Learners worked in groups with peers (Moll, 2002). They listened to and made sense of the ideas from other learners. Learners were asked to share observations and to think about observable phenomenon. This is in line with social constructivism; the theoretical framework for this study asserts that learners construct their own knowledge when they are actively involved in science learning (Vygotsky, 1978).

Learners in the focus group interviews commented on the significance of practical work as demonstrated in the following excerpts:

Learner: Teaching using practical activities makes science easy to understand (Appendix L: L1).

Learner: The challenges that I face are when the teacher does not make examples and when I don't see the real things that we learn about (Appendix Q Refl: NS-5)

Learner: We can see things changing (Appendix L: L3).

Learner: Learning is easier when doing practical work (Appendix L: L5).

The excerpts showed the need to carry out practical tasks and this in turn demands effective planning if practical tasks are to engage the learners holistically. Maselwa and Ngcoza (2003) recommend the use of 'hands-on', 'minds-on' and 'words-on' practical activities in order to enhance learners' understanding of scientific concepts as this is a holistic activity. Effective practical activities build a bridge between what learners can see and handle (hands-on), and scientific aides that account for their observation (brains-on) (Woodley, 2009).

Based on the above arguments, learners were engaged in practical activities involving examples of everyday chemical changes using familiar resources, for example, vinegar and on specialist chemical changes using conventional chemicals, for example, hydrochloric acid as highlighted in Chapter 4. The activities were designed to assess the impact of everyday chemical changes by giving another example, specialist chemical change. Both activities were tested to check the effect of how learners make sense of chemical reactions using familiar resources. The results showed inclusion of everyday contexts as a strategy for teaching science assisting meaning-making of scientific concepts (Kasanda et al., 2005).

Also, engaging learners in social contexts is in line with social constructivism, the theoretical framework for this study. Here emphasis is placed on learners' activities which are directly pertinent to her/his real life and takes place within a culture parallel to an everyday setting (Woo & Reeves, 2007).

Further findings from semi-structured interviews with the focus group indicated that the use of practical activities in the learning of chemical reactions enhances learning. Learner 5 noted that:

L5: *Practical activities help us to know substances that react and those that do not (Appendix L: L5)*

Having this knowledge is crucial as science is everywhere. Reactions in the environment are either chemical reactions or physical. In chemical reactions, new substances are formed (Eilks et al., 2007) and these make the bulk of the major substances that sustain us. On the other hand, chemical reactions may cost the country millions of rands annually trying to curb rusting or corrosion of substances.

L1 asserted that:

L1: *We see what we are doing and practical activities help us to develop more knowledge (Appendix L: L1).*

The learner pointed out that those practical activities helped them to comprehend the reality of the phenomenon and to remember scientific concepts better (L6). This view is reinforced by Wellington (1998) who observes that learners have a natural curiosity of the world around them and much of what they learn is by observation and manipulation. Consequently, tapping into learners' curiosity through practical activities allows learners to extend their knowledge in a way that is natural and developmental (ibid.).

5.4 Analytical Statement 3: Concepts found challenging by learners and their response after mediated activities by a teacher (Appendix M)

This analytical statement describes what learners wrote about their understanding of physical and chemical changes. In the process of making sense of physical and chemical changes, responses indicating conceptual challenges in learners were noted. Also, learners' response after mediated activities in the form of practical activities using familiar resources by teacher.

A number of authors (Hesse & Anderson, 1992; Tsaparlis, 2003; Eilks et al., 2007) argued that learners (aged 12 -18) tend to be confused by physical and chemical changes. The evidence from this study indicates that learners have limited understanding of the differences between physical and chemical changes. Examples were cited in Chapter 4 which supports this contention. Some learners' responses are highlighted below for discussion and analysis. Responses included explanations given by learners when required to identify as well as to justify their choices of physical and chemical changes. The next section starts by analysing and interpreting learners' descriptions of physical phenomena.

Learners' descriptions of physical phenomenon

The following excerpt was extracted from a learner who explained why the level of boiling water in the beaker decreased during heating:

Learner: It's because heat is the destroyer of particles… (Appendix N Diag: MS-1p2)

The above excerpt shows the learner's difficulty in conceptualising physical and chemical changes. Drawing from the work of Stavridou and Solomonidou (1998), learners aged 12-18 find the distinction between physical and chemical phenomena difficult. The authors mention that the distinction is more complex than what practitioners and science textbook authors presently concede. The response by the learner on why the level of water in the beaker goes down if kept boiling for a long time, does not indicate an understanding of the change of state involved. Stavridou and Solomonidou (1998) acknowledge that the heat semantic is used by younger learners before they have received any chemical change instruction and used by older learners about to finish secondary school. The results of this study indicate misconception of everyday meanings different from the scientific meaning (Nakhleh, 1992). Everyday meaning of words interfered in sense-making as learners could not give precise the scientific meaning.

Words like boiling and melting have been specifically noted. On melting of wax when warmed, a learner wrote:

Learner: It's a physical change because when you light it goes down little by little (Appendix M Diag: NS-4p4).

Although the learner could state that melting of white wax was an example of physical change, a sound understanding of the concept was lacking. Interestingly, the learner was describing the change of state process from solid wax to liquid wax as *going down bit by bit*. The use of everyday experiences of observing solid wax melting to form liquid wax was used by the learner to describe the melting of wax. Eilks et al. (2007) point out that personal experiences usually constitute the main source of problems experienced by learners to describe any conceptual difficulties, inconsistent with the accepted scientific definition. The learner provided a descriptive statement of observations of everyday experiences.

Everyday experiences also interfered with sense-making in the following statement:

Iron ball shrinks when it got cooled down (Appendix M Pilo: NS-5p1)

This was the reason given for the question on expansion and contraction of materials. The learner found it difficult to explain expansion and contraction of materials. Eilks et al. (2007) note that concepts of matter and its properties have to be properly introduced in early chemistry teaching prior to introducing chemical and physical changes. This may curb semantic problems in the use of everyday words to describe scientific concepts. Furthermore, they note that the delayed introduction of the particle model of matter may consolidate learners' naïve conception about physical and chemical changes. Thus, particle model of matter may not be an equally-valued basis for learners' interpretation of phenomena. According to Eilks et al. (2007), learners will attempt to explain most phenomena on the macroscopic level without the particulate level. Attempting to explain phenomena at the macroscopic level is noted on the excerpt below as the learners attempt to describe a chemical phenomenon.

Learners' descriptions of chemical phenomenon

Copper roofing are burned by sun and heat (Appendix M Diag: MA-1p1; ML-5p1; etc ;.)

Based on literature describing similar studies, interference of learners' experiences of everyday words; burning and heating, makes it difficult to conceptualise the chemical change happening. Boo (2002) notes that the majority of learners (aged 11-12) use the everyday notion about burning instead of the scientific concepts when describing chemical reactions. Learners are using knowledge captured in the language used in daily talk to describe the change in appearance for copper roofing.

Similar studies by Nakhleh (1992) on the appearance and disappearance of substances in a chemical reaction show that learners' answers indicate that they think that the material (copper roofing in this case) has been modified. Learners argue that what seems to be a new substance is in reality the original substance in an altered form. Copper has simply turned dark due to heat (ibid.). The implication for this is that learners lack an understanding of the conceptions: that copper and oxygen have reacted to form copper oxide. That results in the greenish colour on the roof.

Responses indicating conceptual challenge in learners

Data collected from learners' reflections and from semi-structured interviews with the focus group indicates that learners experience difficulties with the language of learning and teaching (LoLT) and the language of science. Language was not intended to be a factor under investigation in this study but was found to be significant. Learners cannot make sense of scientific concepts if they are challenged in the LoLT and the language of science. "Sense-making is an issue of language" (Weick et al., 2005, p. 409).

The following are learner excerpts from the focus group interviews and learner reflections regarding language:

L5: Many words teacher use, we don't understand them. The words are big for example, hydrochloric acid, limewater and many others (Appendix L: L5).

Learner: We memorise words and soon forget them (Appendix M Refl: MS-5).

L 3: Teachers should mix English and Xhosa to help us understand as these rare words are a problem for us. We lose interest in learning because of these hard words (Appendix L: L3).

In view of the above comments on language problems, the researcher highlighted that language is an indispensable instrument in the promotion of learning (Section 2.3.2). That is, we communicate and understand our world through language. Much of human thought occurs through it (Vygotsky, 1978). It follows that the capability of learners to think and learn depends on their ability to use and understand this crucial medium.

It is evident from the excerpts that if learners are not taught in a language they understand, mediation of learning may become very complicated. The use of English as the sole medium of instruction, is a real possibility to explain the poor performance of learners in science (Appendix L*: L2; Appendix M Refl: MS-5*). Language provides a medium for meaning-making and for interactions between the teacher and the learner. This interaction takes place in an interactive environment as envisaged by social constructivism, the theoretical framework of this study.

Also evident from *Appendix M Diag: MS-1p2; Appendix M Refl: MA-4*, learners are challenged when it comes to elucidating scientific concepts. The descriptive statements for physical and chemical phenomena, which are brief and lacking conceptual understanding, could be attributed to limitations in scientific vocabulary. Learners' language limitation is compounded by the fact that most science materials are written in English and Afrikaans, the languages of examination in our context. The vocabulary and terminology is in English and Afrikaans as well. As a result, learners resort to rote learning and meaningful connections of new and old information becomes impossible. Ultimately, the subject is labelled 'difficult'.

Teachers, who are not proficient in the language of learning and teaching (LoLT), exacerbate the situation (Maselwa & Ngcoza, 2003). These teachers could enhance meaning-making if they used code-switching as a strategy to enhance conceptual understanding. Probyn (2009) posits that when English is used to facilitate learning, it becomes a deterrent towards conceptual mastery. Hence, Probyn (2009) advocates for the use of code-switching to aid understanding. According to the researcher, code-switching is a powerful tool for mediation of learning. Learners in the focus group regarded code-switching as an imperative in promoting scientific concepts. They learn better as the strategy creates dialogue in the classroom, a vital component of social constructivism.

The results from the interview (*Appendix* G*: L5*) indicate that concepts in science are abstract. The instruction of science should commit to introducing learners to the language of science which is abstract in nature (Nakhleh, 1992). Care should thus be exercised in the introduction of scientific terms and emphasis should be put on precise meanings. The language of science should be taught in the same way as any other language. Learners who have not developed their cognitive academic language proficiency (CALP) could be at a disadvantage when studying science as the subject requires an in-depth understanding of concepts acquired by reading textbooks and participating in dialogue (Cummins, 1992). Also mastery of the language of science comes about through interacting with others, within the community of practice (Lemke, 1990). Teaching strategies like repeating key terms and concepts, speaking slowly, using gestures and voice tone to support communication are all necessary to promote conceptual grasp (Probyn, 2009).

Responses indicating conceptual grasp of chemical reactions (Appendix Q)

The above statement describes challenges faced in meaning-making of chemical reactions and how responses linked to the use of familiar resources have enhanced conceptual understanding of scientific concepts.

Evidence of chemical reactions

In their studies on atoms, Eilks et al. (2007), confirm that applying a model of atoms without relating them to the simple particles usually leads to an understanding of chemical reactions as mixtures of the initial products. When changes of matter have two products in the initial stage, learners regard this as a chemical reaction. The following excerpt from the diagnostic and summative tests suggested that learners experienced the problems described above in their descriptions of chemical reactions.

Learner: Chemical reactions happen when we mix different products… (Appendix Q Diag: NL-1p5).

Learner: When you mix two things you are making chemical reaction (Appendix Q Diag: NS-4p5).

Then, from the summative test, learners wrote:

Learner: When two substances are mixed (Appendix Q Summ: ML-2).

Learner: Chemical reaction because mix some products (Appendix Q Summ: ML-2; Summ: MQ-1).

When a teacher says that water consists of hydrogen and oxygen, a learner lacking the concept of atoms and molecules is likely to interpret the teacher's statement as water consists of hydrogen and oxygen mixed (Anderson, 1986). If the concepts of atoms and molecules are not laid-out well, learners describing chemical reactions find it complicated as they are supposed to describe them in relation to molecular terms. Chemical reactions are introduced as changes of discrete particles (Hesse & Anderson, 1992) and the rearrangement of atoms and their constituents' sub-atomic particles form new substances.

Teachers as well as textbooks are to blame for the poor understanding of chemical reactions according to (Eilks et al., 2007) as they do not introduce a clear distinction between the level of discrete particles and the levels of atoms (ibid.). Introducing the particle theory of matter thoroughly consolidates learners' naïve conception about physical and chemical changes (ibid.). Conceptual understanding of the particle theory of matter is one of the keys to unlock and grasp concepts in chemical reactions. The concepts are taught in Grades 4, 6 7 and 8.

Responses indicated that learners' attempt to rearrange simple particles to explain chemical reactions resulted in them conceptualising chemical reactions as a kind of mixing; which are physical processes and not chemical changes.

According to the constructivist learning theory, learning is derived from rich conversation with other people who have similar or different perspectives built on their personal life experiences. Learners come to chemistry lessons with alternative conceptions already formed (Boo & Watson, 2000). Social constructivists do not maintain that all conversation and discussion occurring anywhere anytime are meaningful for learning (Woo & Reeves, 2007) so teachers should be aware of learners' preconceptions and of the nature of these preconceptions in order to address them. They should understand the precise concepts that are held by learners and focus on addressing them to improve understanding of the foundational concept of chemical interaction which infuses the whole subject of chemistry (Boo, 2002).

Responses linked to the use of familiar resources

In the final analysis, learners indicated in the focus group interview and concept maps that using familiar resources helped them to gain a better understanding of chemical reactions. They wrote:

Learner: I prefer to learn with familiar resources because I understand better (Appendix Q Refl: MA-4).

L6: Teachers should use substances we see every day like the ones we were using. Substances we use at home to make learning of chemical reactions easier (Appendix L: L6)

The theoretical framework, social constructivism, consists of situated learning. Learners take part in activities which are directly relevant to their real life and take place within a culture similar to an applied setting (Eilks et al., 2007). The researcher conducted an intervention through lesson presentations using familiar resources in the practical activities. The theoretical framework for this study emphasises the building of knowledge through mediation and negotiation within a learning community (Eilks et al., 2007).

The outcome that emerged from the results in Table 4.2 that is worth mentioning is that there were no clear differences in learner performances to show that learners understood scientific concepts better when familiar resources and conventional chemicals were used. Learners could explicitly state factors that cause rusting; oxygen and the presence of water. The two agents of rusting are common everyday terms learners could easily remember. Learners could define rusting. Nonetheless after two weeks, the percentage of learners that responded correctly dropped from 51% to 14% for the same question in the summative test. The results were contrary to what was anticipated. The reason could be that learners remembered the definition as they completed the worksheets immediately after the lesson. They could easily retrieve the definition from their short memory.

Learners performed well when conventional chemicals were used. They could name reactants of magnesium burning as well as correctly predicting the burning of magnesium. Comparatively, there were no distinct differences in terms of the number of correct responses given by learners when familiar resources were used as well as conventional chemicals.

In the next lesson, learners were more relaxed and engaged in the practical activities of the reaction of the egg and vinegar as well as of calcium carbonate and hydrochloric acid. Interestingly, there was no difference in the results of learner observations (Table 4.3). Learners answered questions using familiar resources and using conventional chemicals well. All learners (100%) correctly stated products of egg and vinegar compared to 69% when conventional chemicals are used. The performance of learners above 50% is evidence of the power of practical activities in enhancing learning as proposed by Maselwa and Ngcoza (2003).

The last lesson on making lemon tea and blowing into clear limewater, to observe colour changes, indicated an improvement in conceptual understanding when learners used familiar resources (Table 4.4). Although the percentages of correct observations were significantly higher in both instances, learners could explain the significance of their observations when familiar resources were used more proficiently.

Finally, the results from the analysis of the summative test on questions the set of lessons presented provided evidence that learners' comprehension of concepts in some chemical reactions when familiar resources were used significantly increased (Table 4.5).The only exception was the question demanding learners to define the term 'rusting'. Learners could not give a precise scientific definition because of vocabulary limitations. Questions set on lessons presented when using conventional chemicals were not done well. In contrast, learners performed significantly better when familiar resources were used. This indicated that learner performance is enhanced when familiar resources are used.

5.5 Concluding remarks

In this chapter, data generated from the pilot study, diagnostic and summative tests; learners' worksheets, focus group interview, learner reflections and mind maps was analysed and interpreted. Three analytical statements were used to discuss the data. Through these statements, the data showed how prior everyday knowledge and practical activities play a crucial role in making sense of some concepts related to chemical reactions. Challenges learners faced with scientific concepts and solutions were identified.

What emerges clearly from this analysis is that learners understand concepts in Natural Sciences when familiar resources are used during practical activities. In the next chapter, the researcher provides a summary of the findings which culminated in recommendations and areas for future research. Limitations of the study are discussed and conclusions drawn.

CHAPTER 6: SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSIONS

6.1. Introduction

The purpose of this study was to investigate how learners make sense of concepts of chemical reactions when familiar resources are used. This chapter presents a summary of the findings of the study, and its limitations. It then makes recommendations for measures to be taken to help enhance learners' conceptual understanding of chemical reactions. Finally, the chapter makes some general recommendations, discusses the limitations of the study, suggests areas for future research and offers some critical reflections.

6.2. Summary of findings

The study reported on how Grade 8 learners make sense of concepts of chemical reactions when familiar resources are used. The study was motivated by the generally poor performance of South African Natural Sciences learners in a series of international benchmark tests referred to as the Trends in International Mathematics and Science Study (TIMSS). TIMSS 1998, 1999 and 2011 reports revealed comparatively poor performance by the South African Grade 8 Natural Sciences learners. The study was also motivated by the researcher's personal experience as a Natural Sciences teacher and his desire to obtain a clearer understanding of what goes on in the Natural Sciences classroom with respect to the learning of chemical reactions. Grade 8 learners at one school were investigated in an effort to find an explanation for their low achievements, specifically in chemical reactions as stipulated by Xipu (2011).

The study took the form of a case study of one school in the Eastern Cape Province, and it focused on Grade 8 learners. It investigated how Grade 8 learners make sense of concepts related to chemical reactions using familiar resources.

The study used both quantitative and qualitative methods to generate data, specifically diagnostic and summative tests, learners' worksheets and interviews. Convenience sampling was used to identify the school. Ethical issues were taken cognisance of throughout the study.

It was found that learners were confused about physical and chemical changes. They could not identify that in physical changes, no new substance is formed and usually the transformation of the substance is easily reversible. In addition, the mass of the substance does not change. Conversely, a new substance is formed in chemical change and usually the transformation of the substance cannot be reversed. The mass of the substance does alter as shown by a nail exposed to rusting agents after weighing (Grade 5, Intermediate phase). In the CAPS documents for intermediate phase (Grades 4-6) and senior phase (Grades 7-8), the topic of physical and chemical changes is not explicitly prescribed for learners to study. Although learners had investigated physical and chemical processes, the curriculum for Grades 4-7 does not acknowledge the phenomena as physical and chemical changes. This is a source of great concern as learners are plunged into learning about chemical reactions in Grade 8 without a sound background on the topic. The distinction between physical and chemical phenomena has to be explicitly clear to learners at the beginning if they are to make sense of the concepts in chemical reactions.

The study further found that when they encountered physical changes like the melting of wax, learners in this study lacked a sound understanding of the concept. They described the change using the everyday experience of observing solid wax melt to form liquid wax (*Appendix I Diag: NS-4p4*). But the personal experiences of the learners constituted the main source of the problem, as they are inconsistent with the accepted scientific explanations. Learners gave descriptive statements of observations of everyday experiences. The inability of learners to explain the melting of wax highlights their poor conceptual understanding of states of matter.

Enough evidence was also found to reveal learners' poor understanding of the expansion and contraction of materials. Learners found it difficult to explain these concepts, which affected their ability to make sense of chemical reactions. Before learners study bond making and breaking in chemical reactions, they need to be introduced to abstract concepts in matter. That is, of matter as consisting of tiny (invisible) particles in motion, which vibrate more when they gain heat energy. Further heating breaks the bonds that hold them and change them into another state. This knowledge prepares learners for learning chemical reactions as the reactions involve the chemical bonds (a bond is a force that holds atoms together) of the reactants breaking and new bonds forming to produce the new products.

Rusting and boiling were concepts that learners found it difficult to give precise meaning to. Rusting is a chemical change and boiling a physical change. Learners lacked the proper vocabulary to describe the observable phenomena happening in both processes. They explained the processes using everyday words with meanings that differ from scientific meaning. The results served to illustrate the poor understanding of physical and chemical changes highlighted in the TIMSS scores.

Learners were engaged in practical activities during instruction. The key point that emerged was that the use of practical activities in the teaching and learning of chemical reactions enhances comprehension of scientific concepts. This is supported by a number of researchers (Maselwa & Ngcoza, 2003; Woodley, 2009; Miller, 2010), who concur that practical work as hands-on learning, prompts thinking about the world we live in. At one point in the study, there were no significant differences in learners' performance when familiar resources and conventional chemicals were used. Learners performed well in both instances, as they were required to give immediate feedback by completion of worksheets. This shows the power of practical work to enhance the learning of scientific concepts, since learners could answer most questions on both worksheets.

As highlighted in the literature, effective practical activities enable learners to build bridges between what they can see and handle (hands-on) and scientific ideas that account for their observations (brains-on) (Woodley, 2009). Teachers should therefore design practical work to prompt the acquisition of this holistic perspective, as science is a social activity which addresses the relationship between science, society and the environment.

The differences in learners' performance emerged during a summative test written two weeks after instruction. Learners performed well in tasks when familiar resources were used. The results suggested that learners better understood scientific concepts when familiar resources were used than when conventional chemicals are used.

The study's findings therefore provide some insightful answers to the research questions.

6.3 Recommendations

The following are some of the recommendations that emerged from the findings.

- **Knowledge embedded in familiar contexts and resources encountered in everyday living**

This study found that using familiar contexts as well as resources has a positive impact on learners' sense-making of concepts in science. The onus lies with teachers to devise more effective strategies to teach science. They should make every effort to connect the science classroom with science in the community (Rennie, 2011). This they can do by incorporating into their teaching tacit and explicit knowledge embedded in everyday household chores and other experiences. Bottles, polish containers, plastic straws, vinegar, egg shells and materials from the kitchen like detergents, to mention just a few, could be useful resources teachers can effectively use to develop scientific concepts. Teachers can engage learners to bring these materials. This does not only improve learner performance in science but assists the teacher to get supplies for teaching and learning in times when funding is not available. Being resourceful is one of the qualities of great teachers.

- **Teaching strategies that encompass the use of familiar resources**

Teachers should team up at school, in cluster groups or as a district to craft detailed lesson plans and learner activities that encompass the use of familiar resources. The worksheets and interviews show that the level of learner engagement increased substantially when learners are learning science using familiar resources. Engaging learners in everyday contexts have motivational effects and thus improve learning. Learners are able to make sense of the concepts taught by relating them to their experiences. The use of familiar resources in this study, ultimately, resulted in improvement compared to using conventional chemicals.

- **Applying everyday knowledge without engaging precise language and concepts**

This study found that learners have difficulties with the language of science. This turned out to be a major obstacle in the learning of science. Learners were applying everyday words which do not have precise scientific meanings to explain and define scientific terms. Clearly, the limitations of learners' science vocabulary are worsened if teachers are not proficient in the LoLT (Maselwa & Ngcoza, 2003).

In view of the above, it is recommended that teachers should be continually developed in scientific literacy. Universities and teachers' training colleges should include scientific literacy as an integral part of their training programme. On-going workshops at provincial, district and cluster/circuit levels should be regularly conducted for teacher development on both LoLT and the language of science. In-service training at school level on strategies for integrating code-switching effectively in the teaching and learning of Natural Sciences should be conducted.

The CAPS document explicitly states that learners should be granted opportunities to regularly read and write in science. For this reason, it is imperative that teachers be engaged in learners' explicit and efficient instruction in reading and writing. School-based assessment, checking for correctness and providing feedback, should be done regularly.

Evidence from the focus group interview showed that learners know what they are talking about, but cannot adequately express their knowledge using the conventional language of science. It follows that there is an urgent need for teachers to shift from traditional ways of teaching and engage learners constructively in meaning-making in science. This entails promoting 'learner talk' (Lemke, 1990) in the classroom. Teachers should refrain from teaching science concepts with learners as passive recipients. Such strategies are obsolete. Instead, contemporary pedagogies that advocate learner-centred education should be the norm of teaching and learning in our classrooms. This calls for great commitment on the part of teachers as they prepare learners for leadership roles today and tomorrow.

- **Applying prior knowledge from concrete experiences observed through the eye to the abstract world of science**

In this study, interference from learners' everyday experiences and prior knowledge made it difficult for them to conceptualise the chemical changes that were happening. The art of teaching of science has become complex because learners in the classroom are coming from diverse cultures and societies. They are from agrarian, coastal, rural, and mining communities, from townships, informal settlements and suburban areas, just to mention a few. They also have different backgrounds and experiences. For the teaching and learning process to be effective, it is essential that the strategy the teacher uses and the design of teaching materials meet the needs created by these diverse backgrounds.

This calls for the integration of prior everyday knowledge by teachers. Teachers should elicit the knowledge learners bring to class in order to plan efficiently and effectively for sense-making. Although it is a challenge to adequately elicit prior everyday knowledge for all learners in the classroom, teachers should make a concerted effort to link teaching activities to learners' everyday experiences, through careful planning. Familiar resources should be used or improvised. The use of familiar resources assists learners not to see science as 'foreign'. They gain deeper insight as they interact with familiar resources in sense-making (Stears, et al., 2003).

Teachers should design lessons to create opportunities for learners to link classroom activities to everyday knowledge. Evidence from the focus group interview and learner reflections show that learners were interested in those aspects of learning that relate to their experience. During lesson delivery using familiar resources, learner motivation was high, which suggests that knowledge, experiences and home have motivational effect and control over learning.

It is recommended that programmes to address how prior everyday knowledge is integrated in the teaching and learning process should be enforced in schools. This is in line with CAPS as it stipulates that "science learnt at school should produce learners who understand that school science can be relevant to everyday life" (Department of Basic Education, 2011, p. 10). The curriculum endorses the integration of indigenous knowledge by suggesting learners' activities that teachers may use to enhance sense-making in science.

- **Effective management of teachers' work should be established**

The diagnostic test and learners' worksheets showed that content and concepts culminating in understanding chemical reactions, like atoms (building blocks of matter), pure elements, elements and compounds, mixtures of elements and compounds, the particle model of matter and changes of state were not adequately covered. These concepts provide a solid foundation for understanding chemical reactions. This had a negative effect on learners' sense-making as there were gaps in their content knowledge.

During this study, the Department of Education was still in the process of appointing the Head of Department for science and mathematics in the school used as the research site. Consequently, there was no mechanism for effective monitoring of the teachers' work. The teacher who was my research participant made it clear that she was a Life Sciences teacher and found it difficult to teach concepts linked to chemistry. This was not convincing as there are numerous chemical reactions pertinent to Life Sciences.

For this reason, peer coaching is recommended in situations where teachers are compelled to teach subjects they did not train for because of a lack of specialist teachers. The school had five teachers for science subjects. Setting up an effective subject committee for mutual support in the teaching of science should contribute to helping learners make sense of scientific concepts.

6.4 Limitations of the study

The focus of this study was to investigate how Grade 8 learners make sense of chemical reactions during lessons involving familiar resources. Due to time, financial and geographical constraints, the study was carried out in only one public high school. As a result, the findings cannot be generalised.

Nevertheless, the study provided some insights into how learners make sense of concepts in chemical reactions when familiar resources are used. The study focused exclusively on how learners make sense of chemical reactions, leaving out the opinion of their teachers. Had the study incorporated teachers' views, more insights might have been generated.

During the interview with the focus group, the tablet used ran short of memory. Several times, the interview had to be stopped to delete some content from the tablet. This could have had repercussions as the tempo of the interview process was interrupted. However, after transcribing the videotaped interviews, transcripts were sent back to the learners. Also, the videotape was replayed several times with learners for them to check that they had not been misrepresented. Learners did not request any amendments to the transcript.

Learners' understanding of the concepts involved in chemical reactions understanding was quite limited, as observed, and this limited the insights they could provide during feedback from worksheets and tests.

The researcher understands that as a newcomer teaching the class for the first time, his presence might have been threatening to some of the participants.

Furthermore, the researcher could not use code-switching as a useful teaching strategy because of the varieties of the learners' home languages.

6.5 Areas for future research

- A similar study could be conducted, but with an increased number of sample schools and with teachers included in addition to learners;
- Further research could be done observing lessons, as the researcher had originally planned, rather than presenting;
- Further research could be done on how practical activities affect the meaningful learning of chemical reactions;
- In addition, further study should be conducted on how the misconceptions that the learners bring in prior everyday knowledge hinder their making sense of science concepts;
- A study should also be conducted on how language affects the making sense of concepts in science teaching and learning; and
- Finally, further research should also be conducted on how teachers could be supported so as to effectively teach chemical reactions concepts using familiar resources.

6.6 Critical reflections

Being a MEd student at Rhodes University helped the researcher gain confidence in being a teacher and start to appreciate some of the qualities that makes teachers great. For example, to be a life-long learner.

The study has helped the researcher to appreciate the value of learner support. The researcher has committed to expanding the learner support currently offered at his school by providing remedial classes for slow learners and enrichment activities for active ones.

As an intermediate science teacher the researcher realised that his role is crucial in ensuring meaningful science learning at high school. Failure on the teachers' part to lay a solid foundation in science in the intermediate and senior phases will have profound effects on learning of high school science later.

It is important that teachers in the intermediate phase work collaboratively with colleagues in the senior phase and at high school. Workshops should be organised to share ideas on how learners make sense of concepts in science. This is likely to result in improved achievement level in Natural Sciences and also may lead learners to consider doing Physical Sciences and Life Sciences as option subjects at Grade 10 level.

The study is underpinned by the tenets of social constructivism, which has been the main teaching and learning tool in the MEd class. The supervisor has consistently reminded us that if you want to walk fast, you walk alone, but if you want to walk longer, as a MEd researcher, walk with others.

The study revealed that learners find the concepts involved in chemical reactions difficult if they are not engaged in practical activities using familiar resources during the learning process. Also, learners find concepts difficult if science teaching and learning is not related to their prior everyday knowledge.

The researcher experienced problems with electronic gadgets. At one point all the information gathered was lost when the laptop was damaged. On top of the damaged laptop, the flash disk the researcher had as back-up got damaged. The researcher had to rely on the computers in the library for most of the work. It was not easy to be in the library most of the time after school work. As a result, the researcher missed valuable workshops from the Department of Education and had to turn down the opportunity to represent the district at provincial level as a Natural Sciences and Technology teacher. The reason was that the researcher wanted more time to engage with the data gathered in this study.

The researcher came to learn that research is a journey on which one needs to walk with others, mindful of the roadblocks one may encounter. These roadblocks are capable of frustrating or diverting one and one can lose sight of the destination in the process.

Lastly, if the researcher was to do this research again, the questioning technique would be improved. Questions in the diagnostic, summative tests and in completed worksheets during interventions had gaps in them. It was challenging to ensure that they related to the research questions. The researcher would also improve the focus group interview questions to cover gaps identified in them.

6.7 Conclusion

This study illuminated the extent to which learners are able to make sense of chemical reactions when familiar resources are used. This was critical in order to improve the mediation of the early learning of chemical reactions at high school level.

The study established that prior knowledge influences the sense-making of scientific concepts. Learners in this study had challenges pertaining to concepts which culminated in impediments to their understanding of chemical reactions. They were not properly instructed in these vital concepts and consequently could not connect well to the abstract concepts of chemical reactions. They resorted to memorising the concepts and this strategy led to poor retention.

Furthermore, the study established that misconceptions occurred because learners came for instruction holding meanings of words that differed from their scientific meanings (Nakhleh, 1992). This prior everyday knowledge contributes to learners' failing to express themselves effectively during instruction. Teachers should introduce scientific terms by emphasising the difference between the everyday meaning and the more precise scientific meaning (ibid.).

Other social factors impeding sense-making include the language of learning and teaching and the language of science. Language is part and parcel of the learner's life. Learners' ability to think and learn depends on their ability to make sense in this crucial medium. It follows that care should be exercised in language use by teachers. Strategies such as code-switching and 'learner talk' (Lemke, 1990) should be adopted in our classrooms to help learners master the LoLT and the language of science.

The study further acknowledged that the use of practical activities, employing familiar resources, enhances learners' sense-making of scientific concepts. This calls for effective planning by teachers to ensure that they marry theory in the classroom with practical activities to ensure that meaningful learning occurs.

The research concludes that there is a need for regular support within the science community of practice at cluster and district levels. Professional development for science teaching is enhanced when teachers meet to discuss strategies to support learners and to find solutions to problems hindering sense-making in contemporary science classrooms.

References

Abrahams, I., & Millar, R. (2008). Does practical work really work? A study of the effectiveness of practical work as a teaching and learning method in school science. *Journal of Science Education, 30*(4), 1945-1969.

Anderson, B. (1986). Pupils' explanations of some aspects of chemical reactions. *Science Education, 70*(5), 549-563.

Ash, D. (2004). "Reflective scientific sense-making dialogue in two languages: The science in the dialogue and the dialogue in the science." *Science Education, 88*(6), 855-884.

Barry, D. (2002). Language equity and assessment in South African education. *Journal for Language Teaching, 361*(142), 105-117.

Bodner, G. M. (1986). Constructivism: A theory of knowledge. *Journal of Chemical Education, 63*(10), 873-878.

Boeijie, H. (2010). *Analysis in qualitative research*. London: Sage Publications.

Boo, H. K. (2002). A burning issue for chemistry teachers. *Teaching Learning, 15*(2), 52-60.

Boo, H. K., & Watson, J. R. (2000). Progression in high school students' (aged 16–18) conceptualizations about chemical reactions in solution. *Science Education, 85*(5), 568-585.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32-42.

Çalık, M., & Ayas, A. (2005). A comparison of level of understanding of grade 8 students and science student teachers related to selected chemistry concepts. *Journal of Research in Science Teaching, 42*(6), 638-667.

Cocks, M. L., Alexander, J., & Dold, T. (2012). *Inkcubeko nendalo*: A Bio-cultural Diversity Schools Education project in South Africa and its implications for inclusive indigenous knowledge systems (IKS) sustainability. *Journal of Education for Sustainable Development, 62*(6), 241-252.

Cohen, L., Manion, L., & Morrison, K. (2011). *Research methods in education* (7th ed.). London: Routledge.

Creswell, J. W. (2003). *Research design: Qualitative, quantitative and mixed methods* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Creswell, J. W. (2014). *Research design: Qualitative, quantitative and mixed methods* (4th ed.). Thousand Oaks, CA: Sage Publications.

Cummins, J. (1992). Language proficiency, bilingualism, and academic achievement. In P.A. Richard-Amato & M.A. Snow (Eds.), *The multicultural classroom: Readings for content-area teachers* (pp. 16-26). New York: Longman.

De Marrais, K. (2004). Qualitative interviews studies: Learning through experience. In K. De Marrais & S. D. Lapan (Eds.), *Fountains for research* (pp. 57-68). Mahwah, NJ: Erlbaum.

Department of Education (DoE). (2011). *Curriculum and Assessment Policy Statement for grades 4-6: Natural Sciences and Technology.* Pretoria.

Department of Education (DoE). (2011). *Curriculum and Assessment Policy Statement for grades 7-9: Natural Sciences.* Pretoria.

Donald, D. L., Lazarus, S., & Lolwana, P. (2002). *Educational psychology in social context.* Cape Town: Oxford University.

Donnelly, R. D., & Fitzmaurice, M. (2005). Designing modules for learning. In G. O'Neill, S. Moore & B. McMullin (Eds.), *Emerging issues in the practice of university of learning and teaching.* Dublin: Aishe. Retrieved (unpaged) from http: //www. Aishe.org/readings/2005-1/

Duckworth, E. (1990). *Science education: A minds-on approach for the elementary years*. Hillsdale, NJ: Lawrence Erlbaum.

Duit, R., & Treagust, D. F. (2003). Conceptual change: A powerful framework for improving science teaching and learning. *International Journal of Science Education*, *25*(6), 671-688.

Eilks, I., Moellering, J., & Valanides, N. (2007). Seventh-grade students' understanding of chemical reactions–Reflections from an action research interview study. *Eurasia Journal of Mathematics, Science & Technology Education*, *3*(4), 271-286.

Freebody, P. (2004). *Qualitative research in education: Interaction and practice.* London: Sage Publications.

Garnett, P. J., Garnett, P. J., & Hackling, M. W. (1995). Students' alternative conceptions in chemistry: A review of research and implications for teaching and learning. *Studies in Science Education, 25*(1), 69-95.

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

Hesse, J., & Anderson, C. W. (1992). Students' conceptions of chemical change. *Journal of Research in Science Teaching, 29*(3), 227-299.

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

Hodson, D. (1996). Laboratory work as scientific method: Three decades of confusion and distortion. *Journal of Curriculum Studies, 28*(2), 115-135.

Howe, A. C. (1996). Development of science concepts within a Vygotskian framework. *Science Education, 80*(1), 35-51.

Howie, S. J. (2001). *Mathematics and science performance in grade 8 in South Africa 1998/1999*. Pretoria: Human Sciences Research Council.

Jawahar, K. (2008). *Exploring the use of functional language features to promote scientific literacy by four physical science educators in Pietermaritzburg.* Unpublished master's thesis, Education Department, University of KwaZulu-Natal.

Johnson, P. (2000). Developing students' understanding of chemical change: What should we be teaching? *Chemistry Education: Research and Practice in Europe, 1*(1), 77-90.

Johnstone, A. H., & Selepeng, D. (2001). A language problem revisited. *Chemistry Education: Research and Practice in Europe, 2*(1), 19-29

Jones, M. G., & Brader-Araje, L. (2002). The impact of constructivism on education: Language, discourse, and meaning. *American Communication Journal, 5*(3), 1-10.

Kasanda, C., Lubben, F., Goaseb, N., Kangeo-Marenga, H., & Campbell, B. (2005). The role of everyday contexts in learner-centred teaching: The practice in Namibian secondary schools. *International Journal of Science Education, 27*(17), 1805-1823.

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

Kitao, K. D., & Kitao, S. K. (2014). *Selecting and developing teaching/learning materials*. Retrieved (unpaged) from http://iteslj.org/articles/Kitao-Materials.html

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

Krajcik, J. S. (1991). "Development of students' understanding of chemical concepts". *The Psychology of Learning Science*, 117-147.

Krueger, R. A. (2008). *Focus groups: A practical guide for applied research* (4th ed.). Thousand Oaks, CA: Sage Publications.

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

Lemke, J. L. (1990). *Talking science: Language, learning and values*. London: Abex Publishing.

Leshen, S., & Trafford, V. (2007). Overlooking the conceptual framework. *Innovations in Education and Teaching International*, *44*(1), 93-105.

Lincoln, S., & Guba, E. G. (1985). *Naturalistic Inquiry*. Newbury Park, CA: Sage Publications.

Lyle, J. (2003). Stimulated recall: A report on its use in naturalistic research. *British Educational Research Journal*, *29*(6), 861-878.

Maluleka, S. (2011, August 10). Curriculum: Back to the blackboard. *Daily News*, p. 3.

Maselwa, M. R., & Ngcoza K. M. (2003). ‘Hands- on’, ‘Minds-on’ and ‘Words-on’ practical activities in electrostatics: Towards conceptual understanding, In D. Fisher & T. Marsh (Eds.), *Proceedings of the third International Conference on Science, Mathematics and Technology Education* (pp. 649-658). Rhodes University, East London Campus, South Africa.

McKernan, J. (1996). *Curriculum action research: A handbook of methods and resources for the reflective practitioner* (2nd ed). London: Kogan Page.

McRobbie, C., & Tobin, K. (1997). A social constructivist perspective on learning environments. *International Journal of Science Education*, *19*(2), 193-208.

Merriam, S. B. (2009). *Qualitative research: A guide to design and interpretation.* San Francisco: Jossey Bass.

Meyer, H. (2004). Novice and expert teachers' conceptions of learners' prior knowledge. *Science Education*, *88*(6), 970-983.

Miller, R. (2004). *The role of practical work in the teaching and learning of sciences*. Paper prepared the Committee: High School Science Laboratories. Washington, DC: University of York.

Miller, R. (2010). *Developing students’ understanding of science: The role of practical work*. Proceedings of the Melodelab Conference (pp. 1-20), Copenhagen.

Miller, P. H., Blessing, J. S., & Schwartz, S. (2006). Gender differences in high-school students, views about science. *International Journal of Science Education, 28*(4), 363-381.

Moll, I. (2002). Clarifying constructivism in a context of curriculum change. *Journal of Education*, *27*(1), 5-31.

Monyani, R. B., & Nieman, M. M. (2006). *The educator as mediator of learning*. Pretoria: Van Schaik.

Mortimer, E., & Scott, P. (2003). *Meaning making in secondary science classrooms*. New York: McGraw-Hill Education.

Mouton, N. (1996). *Understanding social research*. Pretoria: Van Schaik Publishers.

Mouton, N., Louw, G. P., & Strydom, G. L. (2012). A historical analysis of the post-apartheid dispensation education in South Africa (1994-2011). *International Business and Economics Research Journal*, *2*(2), (unpaged).

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

Nachmias, C. F., & Nachmias, D. (1996). *Research methods in the social sciences*. Duffield, UK: Worth Publishers.

Nakhleh, M. B. (1992). Why some students don't learn chemistry: Chemical misconceptions? *Journal of Chemical Education*, *69*(3), 191-196.

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

Oloruntegbe, K. O., & Ikpe, A. (2011). Eco-cultural factors in students' ability to relate science concepts learned at school and experiences home: Implication for chemical education. *Journal of Chemical Education, 8*(3), 266-271.

Probyn, M. (2006). Language and learning science in South Africa. *Language and Education*, *20*(5), 391-414.

Probyn, M. (2009). 'Smuggling the vernacular into the classroom': Conflicts and tensions in classroom code switching in township/rural schools in South Africa. *International Journal of Bilingual Education and Bilingualism*, *12*(2), 123-136.

Rallis, S. F., & Rossman, G. B. (2012). *Research journey: Introduction to inquiry*. New York: Guildford Press.

Rennie, L. J. (2011). Blurring the boundary between the classroom and the community: Challenges for teachers' professional knowledge. In D. Corrigan, J. Dillon & R. Gunstone (Eds.), *The professional knowledge base of science teaching* (pp.13-29). New York: Springer.

Rogers, B. (2000). "Using a teaching model to correct known misconceptions in electrochemistry." *Journal of Chemical Education*, *77*(1), 104.

Roschelle, J. (1995). *Learning in interactive environments*: *Prior knowledge and new experience.* Public Institutions for Personal Learning. Retrieved April 13, 2010, from http://www.exploratorium.edu/IFI/resources/museumeducation/priorknowledge.html

Scott, P. (1998). Teacher talk and meaning-making in science classrooms: A Vygotskian analysis and review. *Studies in Science Education, 32*(1), 45-80.

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

Silverman, D. (Ed.). (2010). *Qualitative research* (3rd ed.). London: Sage Publications.

Stavridou, H., & Solomonidou, C. (1998). Conceptual reorganization and the construction of the chemical reaction concept during secondary education. *International Journal of Science Education*, *20*(2), 205-221.

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

Stewart, D. W., & Shamdasani, P. N., & Rook, D. (2006). *Focus groups: Theory and practice* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Steyn, H. J., Steyn, S. C., De Waal, E. A. S., & Wolhuter, C. C. (2011). *South African education system*. Potchefstroom: Keurkopie.

Sutton, C. (1995). The scientific model as a form of speech. *Research in Science Education in Europe*, 143-152.

Terre Blanche, M. T., Durrheim, K., & Painter, D. (2006). *Research in practice: Applied methods for the social sciences* (2nd ed.). Cape Town: University of Cape Town Press.

Tiberghien, A. (2000). Designing teaching situations in the secondary school. In R. Millar, J. Leach & R. Osborne (Eds.), *Improving science education: The contribution of research* (pp. 27-47). Buckingham: Open University Press.

TIMSS. Department of Basic Education. (2011). *International results in science: TIMSS.* Lynch School of Education, International Study Center (pp. 203-247). Boston: Boston College.

Tsaparlis, G. (2003). A comparison of level of understanding of eighth grade students and science student teachers related to selected chemistry concepts. *Journal of Research in Science Teaching*, *42*(6), 638-667.

Tsaparlis, G. (2003). Chemical phenomena versus chemical reactions: Do students make the connection? *Chemistry Education Research and Practice, 4*(1), 31-43.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological process*. Cambridge, MA: Harvard University Press.

Vygotsky, L. S. (1962). *Language and thought*. Ontario, Canada: Massachusetts Institute of Technology Press.

Weick, K. E., Sutcliffe, K. M., & Obstfeld, D. (2005). Organizing and the process of sense-making. *Organization Science*, *16*(4), 409-421.

Wellington, J. (1998). *Practical work in school science*. *Which way now?* London: Routledge.

Wellington, J., & Osborne, J. (2001). *Language and literacy in science education*: Buckingham: Open University Press.

Woo, Y., & Reeves, T. C. (2007). Meaningful interaction in web-based learning: A social constructivist interpretation. *The Internet and Higher Education*, *10*(1), 15-25.

Wood, D., Brunner, J., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Psychology*, *17*, 89-100.

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

Xipu, B. (2011). *An investigation of how natural sciences teachers mediate learning of chemical reactions in grade 9: A case study*. Unpublished master's thesis, Education Department, Rhodes University, Grahamstown.

Yin, R. K. (2009). *Case study research: Design and methods*. Thousand Oaks, CA: Sage Publications.

Appendices

Appendix A

18 February 2015

Dear Principal

My name is Mashozhera Farasten and I am a M.Ed. student registered at Rhodes University in Grahamstown. My telephone number is 0785523836.

As my research project, I have chosen to conduct research on the interaction between educator and learners at your school. The project title is: A case study of how grade 8 Natural Sciences learners make sense of chemical reactions during lessons involving easily accessible resources. The focus of my study deals in particular, with sense making of chemical reactions during Natural Sciences lessons. Your school's context, suites the requirements I wish to study.

If you decided not to participate you will not be disadvantaged in any way. If you decided to participate, I will prepare lessons of about an hour in length with the Natural Sciences educator identified. I will then need to record about 3 lessons in the Grade 8 classroom being taught by particular Natural Sciences educator, with the consent of both you and the educator. The recording will be stored at Rhodes University for a period of 5 years after use, and then be destroyed. **Your name, the name of your school as well as the name of the principal will not appear in my thesis, or in any other papers or presentations prepared by me regarding the study. There is no cost or additional responsibilities for the school, for you or the principal of the school and you may withdraw from the study at any stage and for any reason**

My research project is being supervised by Dr K.M. Ngcoza, Mr K. Jawahar & Mrs J. Sewry from Faculties of Education and Chemistry. If you need further information about the project please contact Dr K.M.Ngcoza. His telephone number is 0788852143.

If you agree to participate in my research, please complete the attached consent form and if possible, call me on the number mentioned earlier, so I may collect the declaration form. I thank you for taking the time to read this letter.

Yours sincerely

Mashozhera Farasten

(Please complete the declaration below, and let me know when I may collect it).

I …[illegible]… (full name of principal), the principal of …[illegible]…(full name of school) hereby confirm that I understand the contents of this documents and the nature of the research project, and I consent to participating in the research project.

I understand that I am at liberty to withdraw from the project at any time.

Name of Principal	**Signature of Educator**	**Date**
Mr M.S. KOLITI	Mashozera	18/02/2015

Appendix B

18 February 2015

Dear Educator

My name is Mashozhera Farasten and I am a M.Ed. student registered at Rhodes University in Grahamstown. My telephone number is 0785523836.

As my research project, I have chosen to conduct research on the interaction between educator and learners at your school. The project title is: A case study of how grade 8 Natural Sciences learners make sense of chemical reactions during lessons involving easily accessible resources. The focus of my study deals in particular, with sense making of chemical reactions during Natural Sciences lesson. Your school's context, suites the requirements I wish to study.

If you decided not to participate you will not be disadvantaged in any way. If you decided to participate, I will prepare lessons of about an hour in length with you. I will then need to record about 3 lessons in the Grade 8 classroom being taught by you, with the consent of both you and the principal. The recording will be stored at Rhodes University for a period of 5 years after use, and then be destroyed. **Your name, the name of your school as well as the name of the principal will not appear in my thesis, or in any other papers or presentations prepared by me regarding the study. There is no cost or additional responsibilities for the school, for you or the principal of the school and you may withdraw from the study at any stage and for any reason**

My research project is being supervised by Dr K.M. Ngcoza, Mr K. Jawahar & Mrs J. Sewry from Faculties of Education and Chemistry. If you need further information about the project please contact Dr K.M.Ngcoza. His telephone number is 0788852143.

If you agree to participate in my research, please complete the attached consent form and if possible, call me on the number mentioned earlier, so I may collect the declaration form. I thank you for taking the time to read this letter.

Yours sincerely

Mashozhera Farasten

(Please complete the declaration below, and let me know when I may collect it).

I .... (full name of educator), an educator at .... School......(full name of school) hereby confirm that I understand the contents of this documents and the nature of the research project, and I consent to participating in the research project.

I understand that I am at liberty to withdraw from the project at any time.

Name of Educator	Signature of Educator	Date
NTOMBEKHAYA DIPI	....	18/03/2015

Grahamstown, 6143

Appendix C

24 March 2015

Mzali Obekekileyo

Isicelo sokusebenzisana nomntwana wakho kumsebenzi wezifundo endizenzayo:

Ndingutishala wezenzululwazi, kwaye ndikwanguye nomfundi waseDyunivesiti yaseRhodes. Igama lam ndingu Mnu. Mashozhera ofundisa eSDA Primary School. Iinombolo zomnxeba wam zezi zilandelayo, (078 552 3836).

Ngokuzithoba okukhulu ndicela imvume yokusebenza nomntwana wakho kuphando lwezifundo endizenza phantsi kweDyunivesiti yase Rhodes. Umnqweno wolu phando lwam kukukhulisa ulwazi lwabantwana nootitshala ngokunjalo, kwizifundo ezenziwa kwizikolo zethu. Akunyanzelekanga ukuba umntwana avume okanye nawe njengomzali undivumele ukusebenza nomntwana wakho nangona ingaligaiel, elikhulu kum nakuye ukuba ndingavumeleka ukusebenza naye. Ukuba uyandivumela ukusebenza nomntwana wakho, ndiyathembisa ukuba igama lakhe andizokulisebenzisa kwiziphumo zophando lwam. Lo nto ithetha ukuba uzakuhlala ekhuselekile kolu phando.

Ukuba uyandivumela njengomzali ukusebenzisana nomntwana wakho ndicela undisayinele kwesisivumelwano singezantsi.

Enkosi, owakho ozithobilwyo

Mashozhera

Mnimzana Mashozhera

Isivumelwano:

Mna Mnu/Nksk XOLISWA NJADAYI ndiyakuvumela/andikuvumeli ukuba ungasebenzisana nomntwana wam u APHELELE NJADAYI.

Enkosi.

Mnu/Nksk X.M. Njadayi (indawo yokusayina).

Appendix D

<u>25 March 2015</u>.

I understand the contents of this document/letter and the nature of the research project, and I consent to participating in the research project. I understand that I am at liberty to withdraw from the project at any time.

NUMBER	NAME OF STUDENT	SIGNATURE OF STUDENT
1	Macabe Anelisa	[illegible]
2	Madikwa Kamva-Elihle	[illegible]
3	Madlavu Avukonke	
4	Mafilika Patricia	[illegible]
5	Mahini Nkosintle	[illegible]
6	Makasi Buntu	[illegible]
7	Makasi sinazo	[illegible]
8	Makina Zenande	[illegible]
9	Malawu lithemba	[illegible]
10	Mangi Nosiphiwo	[illegible]
11	Mani Senathi	S.mani
12	Manzi Bulelani	[illegible]
13	Maphikana Hlumelo	
14	Matiwana Lithabo	L.Matiwana
15	Matiwane Lufuno	[illegible]
16	Matomela Siphelihle	S.Matomela.
17	Mdoko Athenkosi	[illegible]
18	Mginywa Lymnandy	
19	Mgogo masonwabe	[illegible]
20	Mila bongisa	[illegible]
21	Minnie Sibabalwe	[illegible]
22	Mngcame Luviwe	[illegible]
23	Mngcongo Liyema	[illegible]
24	Momoza Sandisiwe	[illegible]
25	Mpioyane Asemahle	[illegible]
26	Mpofu Siphelele	
27	Mpoli Thina	[illegible]
28	Mpolweni Thandiwe	Mpolweni T.
29	Mtirara emihle	E. Mtirara
30	Mtise Nomathamsanqa	[illegible]
31	Mtsiba Anelisa	[illegible]
32	Mtwalo Yonela	[illegible]
33	Mtya Qhawe	[illegible]
34	Naam Sinothando	[illegible]
35	Nabe Abongile	[illegible]
36	Ncanywa Asisipho	A.Ncanywa

37	Ndawuni Sinovuyo	S. Ndawan.
38	Ndyawe Siphosethu	[illegible]
39	Ndyolashe Thandile	[illegible]
40	Ndzipho Liyema	[illegible]
41	Nelani Mziwoxolo	[illegible]
42	Ngcipu Sanele	S. Ngcipu
43	Ngculu Sangenathi	[illegible]
44	Ngece Bulelani	
45	Njadayi Aphelele	

Appendix E

<u>ACTIVITY SHEET</u>

NAME: ____

DATE: ____

<u>INSTRUCTIONS:</u>

1. Choose the correct or is the best answer from the multiple choice questions given (A; B and C).
2. Mark on the appropriate letter with a cross (x).
3. Write down your explanation for your choice on the lines below.

1. My friend says that when water freezes, the molecules get cold and turn hard. Do you agree?

A: Yes I agree

B: I don’t agree

C: I am not sure

<u>Explanation</u>

____

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2. Would you expect a solid iron ball heated on a stove to?

A: be a little smaller than before.

B: be a little larger than before.

C: stay exactly the same.

<u>Explanation</u>

3. Your teacher lit a candle and told you that this was a chemical reaction. What are the reactants (substances reacting) in this chemical reaction?

A: wax and fire

B: wax and oxygen

C: string or wick burning.

Explanation

4. In a physical change, like changing state from a solid to a liquid, the substance itself doesn't really change. How is a chemical change different from a physical change?

A: Atoms and molecules speed up or slow down.

B: A new substance not is formed.

C: A new substance is formed.

Explanation

5. In your opinion, what is a chemical reaction?

A: Is what happens when we mix different products.

B: Is an explosion

C: Is one in which there is a change of substance.

Explanation

6. The teacher boiled an egg for 10 minutes. He asked the student to compare an uncooked egg with the cooked one. Which is the best explanation made by the student?

A: This is an example of a physical change as 'it was an egg and it is still an egg'.

B: A boiled egg is a new product

C: Neither answer A nor B is correct.

Explanation

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7. The roof of the Cathedral in High street has copper roofing. The roof is turning greenish in colour. This is because:

A: Copper roofing sheets are burned by sun's heat

B: It's just that way.

C: A chemical change is taking place because of oxygen in air.

Explanation

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8. If a lump of white wax is warmed, a pool of clear liquid is found in its place. This change of state is an example of:

A: chemical change as wax has changed its form.

B: Physical change as was has changed its form but remain the same substance.

C: Neither a chemical change or physical change.

Explanation

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9. If an iron nail is left outside for a very long time, a quantity of red/brown powder will be found in its place.

A: Mass of the nail increases.

B: Mass of the nail decreases.

C: Mass of the nail remains the same.

Explanation

___

___

___

10. When a beaker of water is boiling, big bubbles form at the bottom and rise to the top. These bubbles are clear- 'see through'. What is inside the bubbles or what are the bubbles made of?

A: There is oxygen and hydrogen

B: There is nothing.

C: Bubbles have air dissolving in water.

Explanation

11. If a beaker of water is kept boiling for a long time, it can be seen that the level of water in the beaker goes down. Why does this happen?

A: Heat destroy the water particles.

B: Water particles are ‘lost’ from the beaker.

C: Neither answer A nor B is correct.

Explanation

12. A slice of bread is held down in a toaster for 10 minutes, a crisp black slice emerge. This slice is black through and through. Imagine you have a slice of bread and one of these black slices on the table in front of you. How many substances would there be on the table?

A: 1

B: 2

C: Neither 1 nor 2 substances.

Explanation

13. Why do ice blocks dissolves faster in hot water than could water?

A: Heat cause a quick chemical reaction.

B: Particles gains heat energy, move quickly and melts.

C: Heat slow down reaction.

Explanation

14. When you heat a solid iron ball on the stove:

A: The number of molecules increase

B: Molecules expand or get larger

C: Molecules stay the same size but further move further apart.

<u>Explanation</u>

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____
____

15. What are things that happen in a chemical reaction?

A: Smelly change.

B: Bubbling change

C: Both A and B are correct.

<u>Explanation</u>

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Appendix F

DIAGNOSTIC TEST ON CHEMICAL REACTIONS

ACTIVITY SHEET: 1 2 June 2015.

NAME: ____ Grade: 8

DATE: ____

INSTRUCTIONS:

1. Choose the correct or is the best answer from the multiple choice questions given.
2. Circle your choice of answer.
3. Write down your explanation for your choice on the lines below.

QUESTIONS

1. The roof of the Grahamstown Cathedral Hall in High street has copper roofing. The roof is turning greenish in colour. This is because:

A: Copper roofing sheets are burned by sun's heat

B: A chemical change is taking place.

C: There are plants growing there.

D: It is underneath coating coming out.

Explanation

____

____

____

2. If an iron nail is left outside for a very long time, a quantity of red/brown powder will be found in its place. If you weigh the brown powdered iron on the scale, what could be the possible observations?

A: Mass of the nail increases.

B: Mass of the nail decreases.

C: Mass of the nail remains the same.

D: Mass of nail increase and then suddenly decrease.

Explanation

____

____

____

4. When a beaker of water is boiling, big bubbles form at the bottom and rise to the top. These bubbles are clear- ‘see through’. What is inside the bubbles or what are the bubbles made of?

A: There is oxygen and hydrogen

B: There is nothing.

C: Bubbles are air dissolving in water.

D: Bubbles are water vapour.

<u>Explanation</u>

____
____
____

4. If a beaker of water is kept boiling for a long time, it can be seen that the level of water in the beaker goes down. Why does this happen?

A: Heat destroy the water particles.

B: Water particles are ‘lost’ from the beaker.

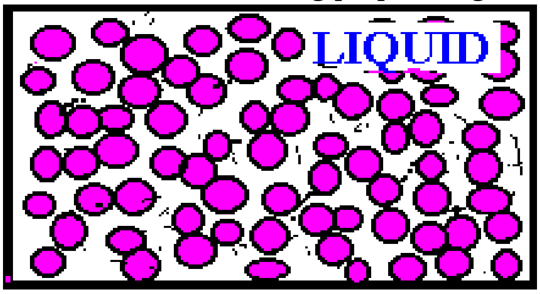
C: Water particles are condensing.

D: Water particles cannot go down.

<u>Explanation</u>

____
____
____

5.Which of the following properties give the best description for particles in a liquid state:



A: Have a strong force holding them together

B: Have weaker forces between them.

C: Have extremely weak forces between them.

C: Move very fast.

Explanation

____

____

____

5. Complete the following statement with the appropriate word from the list below:

All matter is made up of the smallest building blocks called ______________. They are very, very small and everywhere, even in the food we eat.

A: Compounds

B: Elements

C: Atoms

D: Mixtures.

Explanation

____

____

____

6. Fill in the correct word:

An ______________ consists of atoms of only one kind, such as hydrogen (H) and chlorine (Cl). It cannot be separated or broken down into another simpler substance.

A: Compound

B: Element

C: Atoms

D: Mixture.

Explanation

___

___

___

8.A slice of bread is held down in a toaster for 10 minutes, a crisp black slice comes out This slice is black all the way through. Imagine you have a slice of bread and one of these black slices on the table in front of you. How many substances would there be on the table?

A: 1

B: 2

C: 1; 2 and 3

D: All of the above.

Explanation

___

___

___

9. The teacher boiled an egg for 10 minutes. He asked the student to compare an unboiled egg with the boiled one. Which is the best explanation made by the student?

A: This is an example of a physical change.

B: A boiled egg is a new product

C: This is an example of a chemical change as ‘it was an egg and it is still an egg’.

D: A boiled egg is not a new product.

Explanation

10. If a lump of white wax is warmed, a pool of clear liquid is found in its place. This change of state is an example of:

A: Chemical change as wax has changed its form.

B: Physical change as wax changed its form but remain the same substance.

C: Chemical change as wax has not changed its form.

D: Physical change as wax has changed its form.

Explanation

11. When you heat a solid iron ball on the stove:

A: The number of molecules increase

B: Molecules expand or get larger

C: Molecules stay the same size but further move further apart.

D: Molecules stay the same but move closer to each other.

Explanation

12. A burning candle (on question 10) is an example of a chemical reaction. Which are the reactants (substances reacting) in this chemical reaction?

A: wax and fire

B: wax and oxygen

C: string or wick burning.

D: Wax and wick burning.

Explanation

13. Magnesium is burnt to produce magnesium oxide and excess heat. This is an example of a chemical change. How is a chemical change different from a physical change?

A: Atoms and molecules speed up or slow down.

B: A new substance is not formed.

C: A new substance is formed.

D: A chemical change can be reversible by physical means.

Explanation

14. Using the burning of magnesium as an example, which of the following describe a chemical reaction?

A: It is what happens when we mix different products.

B: It is an explosion of a balloon.

C: It is one in which there is a change of substance.

D: It does not have products and reactants.

Explanation

15. What are some of the things that happen in a chemical reaction?

A: Always accompanied by a smelly change.

B: Bubbles are always formed.

C: There is bond breaking and bond forming.

C: Reactants are produced.

Appendix G

LESSON PLAN: 1 Grade: 8

27 July 2015 Time: 45 minutes

Topics: Oxidation of iron and Magnesium.

Lesson objectives:

State observations of the reactions.

Explain the observations.

Identify reactants and products in the reactions.

Share group observations (Test sense-making. Do the groups get the same results?).

Materials used:

Familiar resources: Oxidised mathematical sets and partial new mathematical sets to compare effects of rusting.

Specialist resources: Magnesium ribbons.

Introduction: I introduced the topic by:

Bringing household chemicals and discussed about them. Eliciting from learners examples of bases and acids done in grade 7. Then, asking learners about to give their own examples of chemicals from home and examples in the environment. Then, the concept of chemical reaction was introduced and I asked learners to share their examples of chemical reactions. Some examples shared included photosynthesis, decaying, burning and drying of leaves.

Activity 1: Oxidation of iron

I gave each group two sets of mathematical sets. One was heavily oxidised and the other partially new. Learners were instructed to observe the two sets. I asked questions about rusting and its effects. A classroom discussions ensued on observations and some ways to prevent rusting.

Familiar resources: Oxidised mathematical sets.

Specialised resources: Magnesium ribbon.

Activity 2: Oxidation of magnesium.

Burning magnesium ribbon in a flame. *Caution:* Learners were cautioned not look directly into the magnesium flame as it burns as it may hurt their eyes. They were asked to burn the ribbon on candle flame. I had to scrap some ribbons with sand paper to remove the oxide layer that was preventing burning.

Method:

Learners were instructed to place magnesium ribbon onto the flame of a burning candle and observe.

I asked the learners to discuss the following questions in groups and later report to the class.

1. What will happen if you place magnesium ribbon on the candle flame? ------------------------
----
----

2. What do you think are the **reactants** involved? (The substances that react with each other are called reactants and the new substances that form during a chemical reaction are called products). ---

3. And what **products** are formed? --

5. Can you explain why the change takes place? ---

To conclude the lesson, learners were given worksheets to complete. The written activities were given to determine their understanding of the topic and to check the impact of everyday chemical change by giving another example- specialist chemical change example.

Appendix G1 Worksheet 1 (Wrk 1)

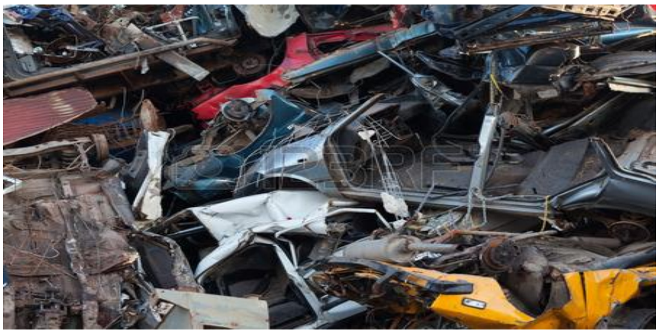
Name: --- 27 July 2015.

Date: --- Grade: 8

Exercise: 1

Answer the exercise on the blank spaces left on the answer sheet. Try to answer all the questions.

1. The picture shows damaged cars that have been rusted.



i. Explain what is rusting? (1)

ii. --

----

iii. Why is it not a useful reaction? (2)

----

iv. How are cars protected from rust? (2)

----

v. Name two factors that cause rusting to happen? (2)

2. *Activity*: Burn magnesium ribbon in a flame. *Caution:* Do not look directly into the magnesium flame as it burns. It may hurt your eyes.

i. What do you predict will happen if you place magnesium ribbon on the candle flame? (1)

---

ii. What do you think are the reactants involved in magnesium burning? (2)

---

iii. And what products are formed? (1)

---

iv. Can you explain why the change take place? (2)

----

3. Copy and complete the following sentences about chemical reactions. Use the words: *PRODUCTS AND REACTANTS ONLY*.

In a chemical reaction, the substances that are produced are called the ---------------------------- of the reaction.

In a chemical reaction, the substances that react with one another are called the ----------------

Substances can react with each other to form ---------------------------- with different chemical properties.

In reactions, re-arrangement of the atoms takes place, to form different ---------------------- (4)

Appendix H

LESSON PLAN: 2 Grade: 8

29 July 2015 Time: 90 minutes

Topics: Egg/Vinegar reaction and Calcium carbonate/Hydrochloric acid reaction.

Lesson objectives:

State observations of the reactions.

Explain the observations.

Identify reactants and products in the reactions.

Share group observations (Test sense-making. Do the groups get the same results?).

Materials used:

Familiar resources: Eggs and Vinegar.

Specialist resources: Calcium carbonate ($Caco_3$), Hydrochloric acid, Beakers and test tubes.

Introduction: I introduced the topic by asking learners about examples of chemical reactions. This was to get an idea of the prior knowledge learners are bringing to the classroom.

Activity 1: The researcher and learners placed an egg in the beaker with vinegar. The egg was 2/3 covered with vinegar and left over the weekend. Observations were done the following Monday, in groups.

Method:

(a) Place your egg shells carefully into the beaker.
(b) Pour the vinegar over the egg shells.

Observations/Results: Learners were asked to answer the following questions in groups:

(a) Can you see anything happening? Describe your observations.
(b) Explain your observations. Why did this happen.
(c) Groups sharing observations, reactants and products.

Activity 2: Lesson continued.

I instructed learners to drop few drops of diluted hydrochloric acid to calcium carbonate in test tube.

Method:

(a) Place calcium carbonate chips into a test tube.

(b) Pour the hydrochloric acid carefully into the test tube with calcium carbonate.

Observations: Learners were asked to answer the following questions in groups:

(a) Can you see anything happening? Describe your observations.
(b) Explain your observations. Why did this happen.
(c) Groups sharing of observations, reactants and products.

To conclude the lesson, learners were given worksheets to complete. The written activities were given to determine their understanding of the topic and to check the impact of everyday chemical change by giving another example- specialist chemical change example.

Appendix H1 Worksheet 2 (Wrk 2)
Name: -- 29 July 2015.

Date: --- Grade: 8

Exercise: 2

Answer the exercise on the blank spaces left on the answer sheet. Try to answer all the questions.

1. The picture shows an egg in vinegar after a period of 24 hours.

fig. 1. An egg after 24 hours.

(a) What did you observe after 24 hours? (2)

(b) Name the two reactants in the reaction? (2)

(c) Why does an egg breakdown in vinegar? (1)

(d) Below is an equation for the chemical reaction between vinegar and egg shells:

Egg shells (98 % Calcium carbonate) + vinegar = calcium acetate + water + carbon dioxide.

Name the products in the above reaction. (3)

----

2. In the **test tube**, few drops of hydrochloric acid were added to powdered calcium carbonate.

   (a) What did you observe? (2)

   (b) Name the two reactants in the chemical reaction. (2)

   (c) Below in an equation for the chemical reaction between hydrochloric acid and calcium carbonate:

Calcium carbonate + hydrochloric acid C~~alcium chlorid~~e + water + carbon dioxide.

Name the products in the chemical reaction. (3)

   (d) What things have happen in reactions in question 1 and question 2 which shows that a chemical reaction has taken place? (3)

   (i) ---

   (ii) ---

   (iii) ---

(18 Marks)

Appendix I

<u>LESSON PLAN</u>: 3   <u>Grade</u>: 8

<u>29 July 2015</u>   <u>Time</u>: 45 minutes

<u>Topics</u>: Making lemon tea and blowing with a straw through clear limewater.

<u>Lesson objectives</u>:

State observations of the reactions.

Explain the observations.

Identify reactants and products in the reactions.

Share group observations (Test sense-making. Do the groups get the same results?).

<u>Materials used:</u>

<u>Familiar resources</u>: Lemon (acid) and Black tea (indicator).

<u>Specialist resources</u>: Limewater and test tubes.

<u>Introduction:</u> I introduced the topic by asking learners about examples of chemical reactions. This was to get an idea of the prior knowledge learners are bringing to the classroom.

<u>Activity 1:</u> Making lemon tea.

I brought prepared black tea and poured it into two 100ml beakers. Each group was given two beakers with black tea. Each group was given cut lemons and were asked to squeeze lemon juice into one of the beakers with black tea. Then, learners were asked to compare colour of tea in the two beakers. Learners were asked to share observations in order to learn from one another.

<u>Observations/Results:</u> Learners were asked to answer the following questions in groups:

(d) Can you see anything happening? Describe your observations.
(e) Explain your observations. Why did this happen.
(f) Groups sharing observations, reactants and products.

<u>Activity 2:</u> Blowing through the clear limewater.

I gave learners each a plastic drinking straw and test tube with limewater. I instructed each to blow through the clear limewater and observe colour changes. Learners were asked to share observations and to draw them.

Observations: Learners were asked to answer the following questions in groups:

(d) Can you see anything happening? Describe your observations.
(e) Explain your observations. Why did this happen.
(f) Groups sharing of observations, reactants and products.

To conclude the lesson, learners were given worksheets to complete. The written activities were given to determine their understanding of the topic and to check the impact of everyday chemical change by giving another example- specialist chemical change example.

Appendix I 1 Worksheet 3 (Wrk 3)

Lesson: 3 Grade: 8

29 July 2015

Topics:Blowing of carbon dioxide in clear limewater.

Question 1

Activity: Add abut 2cm limewater to a test tube. Blow through a drinking straw to bubble carbon dioxide through the lime water solution.

i. What do you observe? (1)

----

ii. Explain your observations. Why did this happen? (2)

----

iii. What are the reactants for the reaction? (2)

Question 2

Activity: Pour the same amount of black tea into each of the two test tubes.
Add a little lemon juice to one of the test tubes of black tea.
Leave the second test tube with only black tea.
Compare the colour of the black tea in the two test tubes.
Empty and rinse out the test tubes.

fig. 1. *Making of lemon tea*

i. What happened to the tea with the lemon juice in it? (1)

----

ii. Complete the following statement: (1)
Acids, like lemon juice, turn black tea --

iii. When you add lemon juice to black tea, which is the indicator? Give a reason to support your answer. (2)

----

iv. What is an indicator? (1)

----

v. Is the reaction of the lemon juice and black tea a chemical reaction? Give a reason to support your answer. (2)

(12 Marks)

Appendix J

NAME: 14 August 2015.

GRADE: 8 Marks: 50

I hour.

SUMMATIVE TEST: CHEMICAL REACTIONS.

INSTRUCTIONS AND INFORMATION

- This paper consists of 5 pages.
- Read all questions carefully before you start answering.
- Answer all questions in the answer sheet provided.
- Number your answers correctly according to the numbering system used in this question paper.
- Write neatly and legibly.

1.1 If a pile of screws is left outside for a very long time, a quantity of red/brown powder will be found on the screws as shown on figure 1. This process is called rusting.

Fig.1: *Pile of rusting screws*

1.1.1 Define the term 'rusting'. (1)

1.1.2 Name any factor that causes iron to rust. (1)

1.1.3 Is rusting a physical or chemical change? Give reason for your answer. (2)

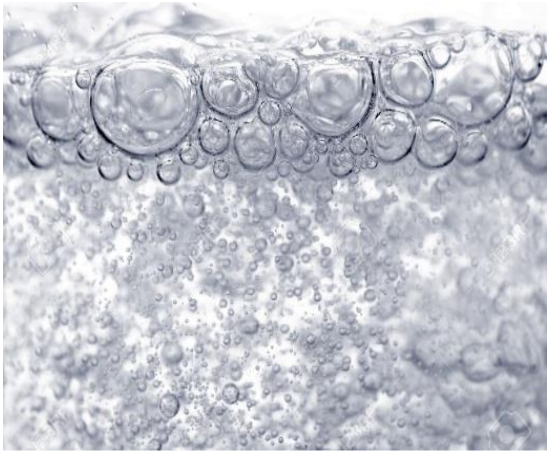
1.2 If a lump of white wax is warmed, a pool of clear liquid is found.

1.2.1 Is this change physical or chemical? (1)

1.2.2 Give a reason for your answer in question 1.2.1 (1).

1.3 When a beaker of water is boiling, big bubbles form at the bottom and rise to the top. These bubbles are clear- 'see through' as shown on figure 2 below:

Fig. 2: *Bubbles* ***of water boiling.***



1.3.1 Is the above process a physical or chemical change? (1)
1.3.2 Give a reason for your answer in question 1.3.1 (1)
1.3.3 Explain how bubbles are formed? (2)
1.3.4 What is inside the clear 'see-through' bubbles? (1)

1.4 A grade 8 learner bubble carbon dioxide into lime water solution for 2 minutes.
Fig. 3: *Learner bubbles into limewater*.

1.4.1 What observations were noted by the learner? (1)

1.4.2 Explain your observations in question 1.4.1. Why did this happen? (2)

1.4.3 What are the reactants for the reaction? (2)

1.5 An egg was put in vinegar and observations were done after a period of 24 hours.

Fig. 4: *The egg after 3 days*.

1.5.1 Describe what was observed. (1)

1.5.2 Identify the reactants of the above reaction. (2)

1.6 The bacteria that live in our mouth create acids. These acids combine with sugar in foods and beverages. The acids may breakdown our teeth.

1.6.1 Give an example of a substance that we use so that our teeth are not 'eaten' away by the acid. (1)

1.6.2 Explain how the choice of your substance works to prevent acids from breaking down our teeth. (1)

1.7 Magnesium ribbon is burned in a candle flame.

1.7.1 Describe the reaction of magnesium burning? (1)

1.7.2 Identify the product(s) when magnesium burns in air. (1)

1.7.3 Explain the changes that take place? (2)

1.8 The following stages show the making of lemon tea from black tea. Carefully study the stages and answer the questions that follow.

Fig. 5: *Making of lemon tea.*

1.8.1 What happened to the black tea when lemon juice was added to it? (1)

1.8.2 Is the reaction of the lemon juice and black tea a chemical reaction? Give a reason to support your answer. (2).

1.9 Choose from the list of words below to complete the following sentences. Write the question number and the answer only on your answer sheet. E.g. 1.9.7 Element.

force	**reactants**	**atoms**	**products**	**form**	**properties**	**break**

In a chemical reaction, the substances that are produced have new and different -------------- (1.9.1) --------. In the reactions, -------- (1.9.2) ---- are re-arranged. A chemical bond is a --------- (1.9.3) ----- that holds -------- (1.9.4) ------------- together. In a reaction, the chemical bonds in reactants-------- (1.9.5) ------and new bonds form in the products. (5)

10. In the **test tube**, few drops of hydrochloric acid were added to powdered calcium carbonate.

10.1What was observe?

(1)10.2 Explain the changes that take place in the reaction of hydrochloric acid and powdered calcium carbonate.

(2)

11. Match the terms in Column A with their correct meaning in Column B. Write only the correct number next to the letter. E.g. 11.8. F.

Column A	**Column B**
11.1 Bond.	A. A basic building block of matter.
11.2Atom	B. Increase in size of a solid when heated.
11.3 Compound.	C. A pure substance which cannot be split up into anything simpler by chemical reactions.
11.4 Element.	D. A force that holds atoms together.
11.5 Expand.	E. A pure substance formed by a chemical reaction between two or more different elements.

(5)

12. State whether the following statements describe a physical or chemical change. The first has been done for you.

E.g. *Bubbles seen when two substances are mixed.* *Chemical change.*

12.1 An ice cube melts. -----------------------

12.2 Trees' leaves decaying -----------------------

12.3 A burning candle. ------------------------

12.4 A boiled egg. -------------------------

12.5 Ripening of fruits. -------------------------

(5)

13. Describe three observations that tells you that a chemical reaction is taking place.

13.1

13.2

13.3. (3).

(50 Marks).

Appendix K

MA-4

16

Name: Asemahle Mpiyane

Date: 27 July 2015 Grade: 8

Exercise: 2

Answer the exercise on the blank spaces left on the answer sheet. Try to answer all the questions.

1. The picture shows an egg in vinegar after a period of 24 hours.

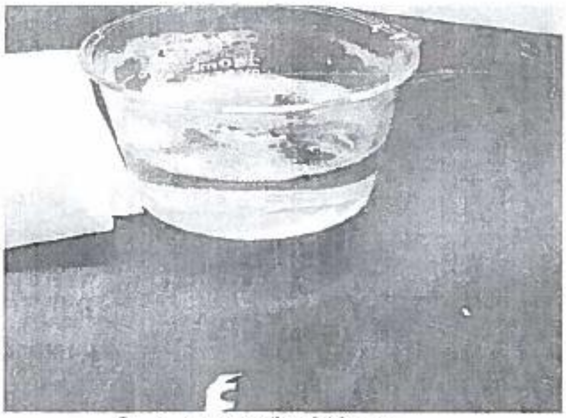


fig. 1. An egg after 24 hours.

(a) What did you observe after 24 hours? (2)

I have observed boubles

(b) Name the two reactants in the reaction? (2)

Vinegar and egg shells

(c) Why does an egg breakdown in vinegar? (1)

Because vinegar has acid and acid is reacting with egg shells

(d) Below is an equation for the chemical reaction between vinegar and egg shells:

Egg shells (98 % Calcium carbonate) + vinegar = calcium acetate + water + carbon dioxide.

Name the products in the above reaction. (3)

calcium acetate, ~~wate~~ water and carbon dioxide are products.

2. In the **test tube**, few drops of hydrochloric acid were added to powdered calcium carbonate.

(a) What did you observe? (2)

It started boiling and the bouble formed

(b) Name the two reactants in the chemical reaction. (2)

Hydrochloric acid and calcium carbonate

(c) Below in an equation for the chemical reaction between hydrochloric acid and calcium carbonate:

Calcium carbonate + hydrochloric acid ⟶ Calcium chloride + water + carbon dioxide.

Name the products in the chemical reaction. (3)

calcium chloride

water

and carbon dioxide

(d) What things have happen in reactions in question 1 and question 2 which shows that a chemical reaction has taken place? (3)

(i) Baubles were formed

(ii) It changed colour

(iii) Heat is produced.

(18 Marks)

MS–I

12/12

Lesson: 8

Topics: Grade: 8

i. Bubbling of carbon dioxide in limewater.
ii. Observing colour change using black tea and lemon juice.

Grade: 8

1. *Activity:* Add abut 2cm limewater to a test tube. Blow through a drinking straw to bubble carbon dioxide through the lime water solution.
   i. What do you observe? (1)

      I've observed the changing of the colour

   ii. Explain your observations. Why did this happen? (2)

      Its because a reaction has taken place and ~~calcium~~ compound of calcium carbonate has been formed

   iii. What are the reactants for the reaction? (2)

      carbon dioxide and lime water.

2. *Activity:* Pour the same amount of black tea into each of the two test tubes.
   Add a little lemon juice to one of the test tubes of black tea.
   Leave the second test tube with only black tea.
   Compare the colour of the black tea in the two test tubes.
   Empty and rinse out the test tubes.

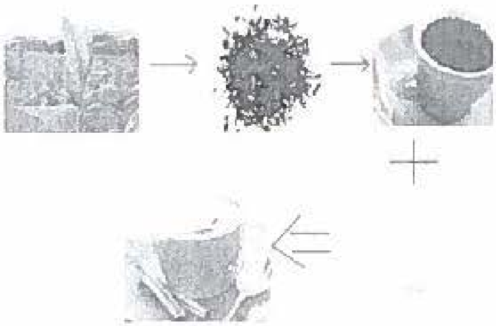


fig. 1 *Making of lemon tea*

   i. What happened to the tea with the lemon juice in it? (1)

      The change of the colour because a chemical reaction has taken place.

   ii. Complete the following statement: (1)

Acids, like lemon juice, turn black tea Brown colour

iii. When you add lemon juice to black tea, which is the indicator? Give a reason to support your answer. (2)

Black tea is the indicator cause it indicates whether a substance is an acid or not

iv. What is an indicator? (1)

An indicator is a substance that indicates whether another substance has an acid.

v. Is the reaction of the lemon juice and black tea a chemical reaction? Give a reason to support your answer. (2)

It is a chemical reaction because ~~of~~ chemicals changed and new substances were formed.

(12 Marks)

ML-3

13

Name: [illegible]

Date: 30 July 2015 Grade: 8B

Exercise: 1

Answer the exercise on the blank spaces left on the answer sheet. Try to answer all the questions.

1. The picture shows damaged cars that have been rusted.

Fig. 1. Damaged-rusted cars

i. Explain what is rusting? (1)

Rusting is a ~~ca~~ chemical reaction wicht contains water and Oxygen

ii. Why is it not a useful reaction? (2)

It does not make things look atractive
It becomes weak

iii. How are cars protected from rust? (2)

By painting them

iv. Name two factors that cause rusting to happen? (2)

Water + Oxygen

2. *Activity:* Burn magnesium ribbon in a candle flame. *Caution:* Do not look directly into the magnesium flame as it burns. It may hurt your eyes.

i. What do you predict may happen if you place magnesium ribbon in the candle flame? (1)

I think it will burn into ~~ashs~~ ashes

ii. What are the reactants involved in magnesium burning? (2)

Magnesium and Oxygen

Magnesium oxide

iii. What products are formed? (1)

Ashes

i. Can you explain why the change take place? (2)

~~It~~ Chemical reaction

3. Copy and complete the following sentences about chemical reactions. Use the words: *PRODUCTS AND REACTANTS ONLY.*

In a chemical reaction, the substances that are produced are called the Products of the reaction.

In a chemical reaction, the substances that react with one another are called the Reactants.

Substances can react with each other to form products with different chemical properties.

In reactions, re-arrangement of the atoms takes place, to form different products (4)

(17 Marks)

9/30

NS-4

DIAGNOSTIC TEST ON CHEMICAL REACTIONS

ACTIVITY SHEET 1

NAME: ______________________ Grade: 8

DATE: ______________________

INSTRUCTIONS:

1. Choose the correct or is the best answer from the multiple choice questions given.
2. Circle your choice of answer.
3. Write down your explanation for your choice on the lines below.

QUESTIONS

1. The roof of the Grahamstown Cathedral Hall in High street has copper roofing. The roof is turning greenish in colour. This is because:

A: Copper roofing sheets are burned by sun's heat

B: A chemical change is taking place.

C: There are plants growing there.

D: It is underneath coating coming out.

Explanation

They turn greenish because the sun's heat, heats the roof and the colour changes

2. If an iron nail is left outside for a very long time, a quantity of red/brown powder will be found in its place. If you weigh the brown powdered iron on the scale, what could be the possible observations?

A: Mass of the nail increases.

B: Mass of the nail decreases.

C: Mass of the nail remains the same.

D: Mass of nail increase and then suddenly decrease.

Explanation

It decrease because when the sun heat it, it will fuse ~~and it~~ ~~en~~

3 When a beaker of water is boiling, big bubbles form at the bottom and rise to the top. These bubbles are clear- 'see through'. What is inside the bubbles or what are the bubbles made of?

A: There is oxygen and hydrogen

B: There is nothing.

C: Bubbles are air dissolving in water.

D: Bubbles are water vapour.

Explanation

Because the bubbles are formed by water and oxygen and hydrigen is water

4. If a beaker of water is kept boiling for a long time, it can be seen that the level of water in the beaker goes down. Why does this happen?

A: Heat destroy the water particles

B: Water particles are 'lost' from the beaker.

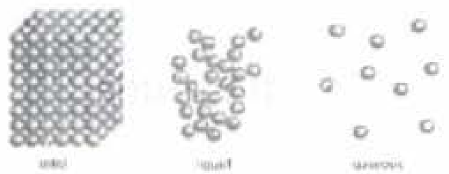
C: Water particles are condensing.

D: Water particles cannot go down.

Explanation

The water particles are destroyed by the heat because it is boiling.

5. Which of the following properties give the best description for particles in a liquid state:



A: Have a strong force holding them together

B: Have weaker forces between them.

C: Have extremely weak forces between them.

C: Move very fast.

Explanation

Because it is a liquid and they have weaker forces between them.

6. Complete the following statement with the appropriate word from the list below:

All matter is made up of the smallest building blocks called Atoms. They are very, very small and everywhere, even in the food we eat.

A: Compounds

B: Elements

C: Atoms

D: Mixtures.

Explanation

Atoms because they are the smallest units that the elements are made of.

7. Fill in the correct word:

An Element consists of atoms of only one kind, such as hydrogen (H) and chlorine (Cl). It cannot be separated or broken down into another simpler substance.

A: Compound

B: Element

C: Atoms

D: Mixture.

Explanation

Because they have hydrogen (H) and Chlorine (Cl) compounds.

8. A slice of bread is held down in a toaster for 10 minutes, a crisp black slice comes out This slice is black all the way through. Imagine you have a slice of bread and one of these black slices on the table in front of you. How many substances would there be on the table?

A: 1

B: 2

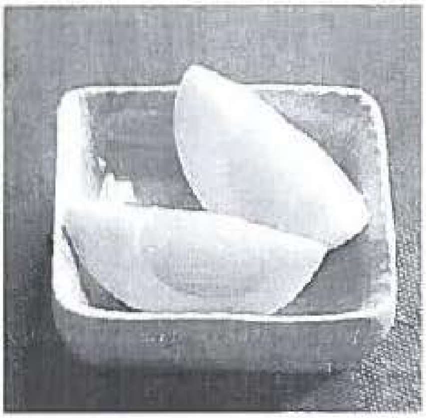
C: 1: 2 and 3

D: All of the above.

Explanation

Yuy can find few substance in a slice.

9. The teacher boiled an egg for 10 minutes. He asked the student to compare an unboiled egg with the boiled one. Which is the best explanation made by the student?



A: This is an example of a physical change.

B: A boiled egg is a new product

C: This is an example of a chemical change as 'it was an egg and it is still an egg'.

D: A boiled egg is not a new product

Explanation

It is an egg the difference is that the other one is boiled.

10. If a lump of white wax is warmed, a pool of clear liquid is found in its place. This change of state is an example of:

A: Chemical change as wax has changed its form.

B: Physical change as wax changed its form but remain the same substance.

C: Chemical change as wax has not changed its form.

D: Physical change as wax has changed its form.

Explanation

Its a physcal change because when you light it it goes down little by littel.

11. When you heat a solid iron ball on the stove:

A: The number of molecules increase

B: Molecules expand or get larger

C: Molecules stay the same size but further move further apart.

D: Molecules stay the same but move closer to each other.

Explanation

They stay closer because they are running away from the heat.

12. A burning candle (on question 10) is an example of a chemical reaction. Which are the reactants (substances reacting) in this chemical reaction?

A: wax and fire

B: wax and oxygen

C: string or wick burning.

D: Wax and wick burning.

Explanation

Because we ~~are~~ the candle that work with out fire

13. Magnesium is burnt to produce magnesium oxide and excess heat. This is an example of a chemical change. How is a chemical change different from a physical change?

A: Atoms and molecules speed up or slow down.

B: A new substance is not formed.

C: A new substance is formed.

D: A chemical change can be reversible by physical means.

Explanation

Because when we are creating a new chemical ~~rea~~ change it means we are creating a substance

14. Using the burning of magnesium as an example, which of the following describe a chemical reaction?

A: It is what happens when we mix different products.

B: It is an explosion of a balloon.

C: It is one in which there is a change of substance.

D: It does not have products and reactants.

Explanation

Because when you mix two things you are making chemical reaction.

15. What are some of the things that happen in a chemical reaction?

A: Always accompanied by a smelly change.

B: Bubbles are always formed.

C: There is bond breaking and bond forming.

C: Reactants are produced.

MA-4

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Grade 8b

Question 1

1.1.1. Rusting is when a metal left outside for a long time and it get rusting.

1.1.2. Water.

1.1.3. It is a chemical change because we can see it changing.

1.2.1. Chemical

1.2.2. Because you can see the change. There are colour change.

1.3.1. Chemical

1.3.2. Because you can see it change and boubles form

1.3.3. When you put a pot with cold water in a heat, the heat burns the water and water starts to boil and the boubles go up and up.

1.3.4. It is water.

1.4.1. Boubles

1.4.2. Because the learner bad blow the water and the boubles formed.

1.4.3. Oxygen and carbon dioxide.

1.5.1. A colour change

1

1.6.2. Vinegar and an egg shell.

x.

1.6.1 Water.

1.6.2. You drink water so that the bacteria that creates acid wont get to breakdown our teeth.

1.7.1. It gets bigger while it is burning and it change into another product.
1.7.2. ~~Oxg~~ Oxygen.
1.7.3. The magnesium burned in heat and it changed it's product into ashes.

18.1. It changed a colour.
18.2. Yes because there was a change that happend

19.1. Products.
1.9.2. Atoms
1.9.3. Force
1.9.4 Properties
1.9.5. Break.

10.1. There was a colour change.
10.2. It was warm and there was a colour change.

11.1. D
11.2. A.
11.3. E.
11.4. C.
11.5. B.

12.1. An ice cube melts — Physical
12.2. Tree's leaves decaying — Physical
12.3. A burning candle — chemical
12.4. A boiled egg — chemical.
12.5. Ripening fruits — chemical.

13.1. Changing colour

Appendix L

Transcript of focus group interview

Q. Some learners would say that the topic on chemical reactions is difficult. What would you tell them?

L1: Some of us we are studying the topic for the first time

Tr : So?

L1: The topic is new, so we sometimes don't understand it.

Tr : What is it that you don't understand?

L2: A lot of things we don't understand (pause)

Tr : Go on

L2: Some words needs a dictionary to understand them.

Tr : You mean, some words in science are difficult to understand?

L5: Many words teachers use, we don't understand them. The words are 'big', for example, hydrochloric acid, limewater and many others.

Tr: Oh !

Tr : Anyone who would like to add something?

Silence

Tr : Anyone to add something

L3: When we don't understand the words used in class, we won't be learning.

Tr: What then should be done?

L3: Teachers should mix English and Xhosa to help us understand as these rare words are a problem for us. We lose interest in learning because of these hard words.

Q. How would you then describe the best way of teaching and learning chemical reactions?

L6: Teachers should use substances we see everyday like the ones we were using. Substances we use at home to make learning of chemical reactions easier to understand.

L1:I will be focused on unfamiliar substances because I fear that it will damage my skin and not focussing on the lesson.

Tr: Anything to add?

L1: Teaching using practical activities makes science easy to understand.

Tr : How does it make understanding easy?

L4: We can see things changing.

L1: We observe chemical reactions happening.

Tr : What else?

Tr : Yes (glancing to a learner who had not said anything)

L5: You can touch.

Tr : Which other sense would you use (fanning with a hand)

L6: Smelling.

L3: Sir, learning is easier when we are doing practical activities.

Tr : Ok

Tr :Q. What of the use of familiar resources? Did you find it as a useful way to learn chemical reactions?

Ye-s (Chorus answer)

L2: Using what we know like eggs and vinegar made us discover what we did not know.

Tr: Like what?

L2: Like vinegar is an acid

Tr: What does an acid do?

L3: It makes egg shell to dissolve

Tr: What other things did we use?

L4: Handy –andy, sunlight liquid

Tr : We didn't use them but I showed you as examples of chemicals from home

L3:Tea

Tr : Black tea (pause); Was their use helpful?

L2: Yes, because we know these things from home.

Tr : What do say (referring to L6)

L6: What do you say? I don't understand

Tr : Using familiar resources from home, was it helpful to understand chemical reactions?

L6: Yes Sir.

L1: The things we know makes it easier to remember science.

L4: Teachers should always give us worksheets to complete after lessons.

Tr : Why?

L4: You can do further study at home.

L3: Use of resources from home is important.

Tr : It makes you like science and studying it.

Tr : Thank you guys!

Tr :Q. Did you find the use of practical activities in the learning of chemical reaction in Natural Sciences useful or not?

L4: Practical activities make science so easy as practical activities are easy to follow

L1: It was useful Sir. Teachers who don't use practical activities makes life difficult.

Tr : Do you agree

L5: We see what we are doing and practical activities help us to develop more knowledge

L2: Teachers write what they want us to do on chalkboard

L4: If teacher says do this on chalkboard, science becomes boring.

Tr : What else are the uses of practical activities?(referring to L6)

L6: Easy to remember and help us to handle substances such as acids.

L3: Practical activities help us to link things we know at home with sciences in the classroom and makes science fun to do

Tr: Anything else:

L5: Practical activities help us to know substances that react and those that do not

Tr: Thank you.

Tr : What was it like for you when you were learning chemical reactions using specialised chemicals and familiar resources?

(Silence)

Tr : We used specialised and familiar chemicals in our lessons. Which part of the lesson have you enjoyed the most?

L4: Specialised

Tr : Which part?

L4: When we were burning magnesium

Tr : Ok which part of the lesson was easier to understand

L1: When we used familiar resources

Tr : Can you explain why you think so?

L1: We don't understand some words of specialised chemicals, the language used we don't understand. E.g. Limewater.

Tr : You mean the language is not familiar

Yes (chorus answer).

Tr : Thank you so much.

END.

Appendix M

ANALYTICAL MEMO (AM) 1: CONCEPTS FOUND CHALLENGING BY LEARNERS (Collated from pilot test, diagnostic test, learners' class worksheets, summative test, learners' concept maps and reflections and from semi-structured interviews with the focus group)

Table A1: Summary of attempts to make meaning from scientific concepts: Which scientific concepts do learners find difficult to construct precise meaning in interpreting chemical reactions? [This will inform Section 5.1 of chapter 5]

Category	Question number (Pilot, Diagnostic and Summative tests)	Learner responses	Source of response/data
Learners' description of physical phenomenon	1	Copper roofing are burned by sun and heat.	Diag: MA-1p1;ML-5p1;MS-4p1;MQ-1p1;NL-2p1 Pilo:MA-1p3;MA-1p4;ML-2p2;MT-2p1;ME-1p2.
	4	It's because heat is the destroyer of particles, meaning that particles are easily destroyed by heat.	Diag: MS-1p2; ML-2p2;MB-3p2;MA-4p2;MQ-1p2

	4	I think the particles would get lost because the heat would have been enough, so they would losen up as particles of gas and disappear	Diag: MZ-1p2
	10	I think so because it would have changed from being solid to liquid, when explains that the form it was before let go the particles and turned into another form	Diag: MZ-1p4
	4	It is heat that destroy because water is kept boiling for a long time	Diag: MN-2p2;MS-2p2;NB-1p2
	2	I think the mass will increase because iron gets more heavier in powder form or any form	Diag:MZ-1p1
	1	The roof is 'getting old'	Diag:MH-1p1;MS-1p1
	2	The nail will be 'old and rusty'	Diag:MH-1p2
	2	Mass of nail decrease because the particles are broken down	Diag:MQ-1p1
	9	This is example of physical change, because the egg turned to a new product which is no longer the liquid. It is solid egg.	Diag:NL-1p3
	2	Mass of nail increases because it has gotten some	Diag:NL-1p1

		nutrients, light and heat from the sun	
	10	It's a physical change because when you light it goes down little by little	Diag:NS-4p4
	2	Iron ball shrinks when it got cooled down	Pilo: NS-5p1
Learners' description of chemical phenomenon			
	1.6.2	It contains calcium and the calcium makes the teeth strong and protected from acid	Summ:MS-1
	1.1.1	Rusting is when the product turns dry or old	Summ:MS-2
	1.1.3	Object which is attracted to rust	Summ:MS-2
	10	Chemical change as wax has changed its form, to become water because it melts	Summ:NL-1p4
	1.2.1	Chemical change you form two substances	Summ:ML-2
	1.2.1	Chemical change because wax changes to clear liquid	Summ:MS-3
	1.1.3	Chemical change because I see it change	Summ:MS-4
	1.3.2	Chemical change because mix some products	Summ:MQ-1
		EGG AND VINEGAR	
		Iganda liyatshinsha ikhala libemhlope	Cm: MA-1
		The shell disappears	Cm:MQ-1

		It eats the shell and change colour	Cm:NS-4
		It develops small bubbles	Cm:NS-4; MZ-1;ML-5
		The egg is eaten up by vinegar until it is soft	Cm:NL-1
		Vinegar eats the shell	Cm:MZ-1
		The shell becomes soft	Cm:NS-1
		The egg is boiling	Cm:NS-1
		BLOWING THROUGH CLEAR LIMEWATER	
		Colour change	Cm:ME-1;MS-2;MA-4;MS-5;ML-2;NS-4;MQ-1
		Changes its colour into complete white	Cm:ML-5
		More bubbles are formed	Cm:MS-1
		Carbon dioxide is added	Cm:NS-1
		Colour changes it turns to milky	Cm:MA-1
		RUSTING	
		When something rust, its make of water and sun	Cm: MB-1;MM-1
		Metal changes colour	Cm:NL-1; MT-1; ML-2; MA-4; MS-2; MZ-1; MS-1; NA-2; ME-1; NS-1; NS-5;ML-5.
Responses that may indicate conceptual		I don't understand the language	Refl: MA-4
		The challenges that I face are when the teachedoen'n do example and when I	Refl:NS-5

challenge to learners		don’t see the reall things that we learn about	
		Many terms we don’t know	Refl:ML-2;MA-4
		Words we don’t understand e.g hydrochloric acid	Refl:MA-4
		WE memorise words and soon forget them	Refl:MS-5
		Boring because of words we don’t understand	Refl:MA-4
		Rare chemicals are a challenge	Refl:MS-1
		I will be focused on unfamiliar resource because of fear that it will damage me – my skin … lesson becomes boring	Refl:MS-1
		Hard to understand	Refl:ML-5;MS-4;ME-1
		(I understand science) when Im taught in English and Xhosa	Refl: NS-5; MS-2;NS-1.
		Words I don’t understand make me lose interest in the subject	Refl:MA-4;NS-1
		The topic is new, so we sometimes don’t understand it.	Fgi:L1
		Some words need a dictionary to understand them.	Fgi:L2
		When we don’t understand the words used in class, we won’t be learning.	Fgi:L3

		Many words teachers use, we don't understand them. The words are big, for example, hydrochloric acid, limewater and many others.	Fig: L5
		Teachers should mix English and Xhosa to help us understand as these are rare words are a problem for us. We lose interest in the learning because of these hard words.	Fig: L3

Key for the respondents:

Diag: MA-1p1- Diagnostic test; Learner code number; page one

Pilo: MA-1p3- Pilot test; learner code number; page 3

Summ: MS-1- Summative test; Learner code number.

Cm: MS-3- Concept maps; learner code number

Refl: ML-2- Reflections; learner code number

Fgi: L3- Focus group interview; Learner 3

Appendix N

ANALYTICAL MEMO 1: APPLYING PRIOR KNOWLEDGE PRACTICES (Collated from pilot test, diagnostic test, learners' class worksheets, summative test, learners' concept maps and reflections and from semi-structured interviews with the focus group)

Table A2: Summary of prior knowledge application in Natural Sciences: WHAT FORMS OF PRIOR KNOWLEDGE ARE BEING APPLIED BY LEARNERS? [This will inform Section 5.2 of Chapter 5]

Category	**Question number**	**Learner responses**	**Source of response/data**
Everyday notions of oxidation of metals.	1	Copper roofing are burned by sun and heat	**Diag**: MA-1p1;ML-5p1;MS-4p1;MQ-1p1;NL-2p1 **Pilo**:MA-1p3;MA-1p4;ML-2p2;MT-2p1;ME-1p2.
	9	Because the rust eats the iron nail and will lose its mass	Pilo: MK-1p3;NS-5p3
	2	Because mass of the nail increases because of the weather outside	Pilo: MT-2p1
	2	The nail will be 'old and rusty'	Diag;MH-1p1
	2	Mass of nail decrease because the particles are broken down	Diag:MQ-1p1

	2	Mass of nail increases because it has gotten some nutrients, light and heat from the sun	Diag:NL-1p1
	1.1	Rusting is when a substance such as water and oxygen gets attracted to an iron or steel	Wrk 1:MS-2
	1.1	Rusting is a chemical reaction which contains water and oxygen	Wrk 1:ML-3
	1.1	Rusting is something that is old	Wrk 1:MM-1
	1.1	Rusting is when something becomes dull with brownish colour	Wrk 1:MQ-1
	2.1	I think it will grow larger because when metal burns it grows due to the heat	Wrk 1:MZ-1
	1.7.3	Magnesium ‘appears’ like fireworks and ashes are formed	Summ:MS-1
		MAGNESIUM BURNING	
		Ashes are formed	Cm: NS-1; MZ-1;MA-4; MS-5
		Light like fireworks	Cm:MZ-1;MA-4;MS-5
		RUSTING (CM)	
		When something rust, its make of water and sun	Cm:CM: MB-1;MM-1
		Powder is formed	Cm:MS-1
		Water causes rust	Cm:NS-1

Uses of everyday prior knowledge to explain scientific concepts	1	Copper roofing are burned by sun and heat	Diag: MA-1p1;ML-5p1;MS-4p1;MQ-1p1;NL-2p1 Pilo:MA-1p3;MA-1p4;ML-2p2;MT-2p1;ME-1p2.
	4	4 Its because the heat is the destroyer of particles, meaning that the particles are easily destroyed by heat	Diag:MS-1p2; ML-1p2; MB-3p2; MA-4p2; MQ-1p2
	4	4 I think the particles would get lost because the heat would have been enough, so they would losen up as particles of gas and disappear	Diag:MZ-1p2
	10	10 I think so because it would have changed from being solid to liquid, when explains that the form it was before let go the particles and turned into another form	Diag: MZ-1p4
	10	Chemical change as wax has changed its form, to become water because it melts	Diag:NL-1p4
	1	The roof is ‘getting old’	Diag:MH-1p1;MS-1p1
	1	Water get cold and turn hard	Pilo:ME-1p1
	3	The water is ‘getting hot’	Diag:MH-1p2
	2	Mass of nail decrease because the particles are broken down	Diag:MQ-1p1

	11	Heat destroy the water particles	Pilo:ML-2p4
	9	This is an example of a physical change, because the egg turned to a new product which is no longer the liquid. It is solid egg	Diag:NL-1p3
	10	It’s a physical change because when you light it goes down little by little	Diag:NS-4p4
	2	Iron ball shrinks when it gets cooled down	Pilo:NS-5p1
	1.1	Rusting is when a substance such as water and oxygen gets attracted to an iron or steel	Wrk 1:MS-2
	1.1	Rusting is a chemical reaction which contains water and oxygen	Wrk 1:ML-3
	1.1	Rusting is when something becomes dull with brownish colour	Wrk 1:MQ-1
	1a	Egg gets bigger	Wrk 2:MS-5
	1c	Egg breaks down	Wrk 2:ML-5
	2a	It starts to boiling	Wrk 2:MB-2;MA-4;NA-3.
		EGG AND VINEGAR	
		Igandaliyatshinshaikhalalibemhlope	Cm:: MA-1
		The shell disappears	Cm:MQ-1
		It eats the shell and change colour	Cm:NS-4
		It develops small bubbles	Cm:NS-4; MZ-1;ML-5
		The egg is eaten up by vinegar until it is soft	Cm:NL-1
		Vinegar eats the shell	Cm:MZ-1
		The shell becomes soft	Cm:NS-1
		The shell fall	Cm:MA-4
		The egg shell brakes	Cm:MS-1

		The egg is boiling	Cm:NS-1
		Egg shell is removed	Cm:ML-5
Everyday notions of boiling	4	Its because heat is the destroyer of particles, meaning that particles are easily destroyed	Diag:MS-1p2; ML-2p2; MB-3p2; MA-4p2; MQ-1p2
	4	I think the particles would get lost because the heat would have been enough, so they would losen up as particles of gas and disappear	Diag:MZ-1p2
	4	It is heat that destroy because water is kept boiling for a long time	Diag:MN-2p2; MS-2p2; NB-1p2
	11	Because the water molecules will burn	Pilo: MK-1p4
	4	Heat is absorbed by water	Diag:MH-1p2
	5	The water is 'getting hot'	Diag:MH-1p2
	11	Heat destroy the water particles	Pilo:ML-2p4
	11	Heat is burning the water	Diag:MA-1p1
	5	Water particles will move very fast	Pilo:MT-2p4
	13	Water is hot and the particles gains heat energy	Pilo:MT-2p4
	4	Water can be destroy	Diag:MA-5p2
	11	Water molecules will burn	Pilo: NS-5p3
	2a	It starts to boiling	Wrk 2:MB-2;MA-4;NA-3
	1.3.1	Chemical change because the water is boiling, which means there is a change	Summ:MS-3
Everyday notions of	4	Its because heat is the destroyer of particles, meaning that particles are easily destroyed by heat	Diag:MS-1p2;ML-2p2;MB-

heating substances			3p2;MA-4p2;MQ-1p2
	2.1	I think it will grow larger because when metal burns it grows due to the heat	Wrk 1:MZ-1
	8	Its because heat creates new substances, e.g boiling water. Boiled water is safer than non-boiled because of heat	Diag:MS-1p2
	1	I think so because once heat get very hot it makes an object change its colour due to the hot heat	Diag:MZ-1p1
	4	I think the particles would get lost because the heat would have enough, and so they would losen up as particles of gas and disappear	Diag:MZ-1p2
	10	It is heat that destroy because water is kept boiling for a long time	Diag:MN-2p2;MS-2p2;NB-1p2
	11	I think it will be a little larger than before because the particles will expand or spread due to heat	Diag:MS-2p4MS-3p4;MA-4p4;NL-1p4
	4	Heat is absorbed by water particles	Diag:MH-1p2
	11	Heat destroy the water particles	Pilo:MT-2p4
	11	Heat is burning the water	Diag:MA-1p1
	13	Water is hot and the particles gains heat energy	Pilo:MT-2p4
	1.2.1	Chemical change because wax change to clear liquid	Summ:MS-3
Uses of everyday language	1.1	Rusting is when a substance such as water and oxygen gets attracted to an iron or steel	Wrk 1:MS-2

	1.1	Rusting is a chemical reaction which contains water and oxygen	Wrk 1:ML-3
	1.1	Rusting is something that is old	Wrk 1:MM-1
	1.1	Rusting is when something becomes dull with brownish colour	Wrk 1:MQ-1
	1a	Egg gets bigger	Wrk 2:MS-5
	1c	Egg breaks down	Wrk 2:ML-5
	2a	It starts to boiling	Wrk 2:MB-2;MA-4;NA-3.
	1	Copper roofing are burned by sun and heat	Diag: MA-1p1;ML-5p1;MS-4p1;MQ-1p1;NL-2p1 Pilo: MA-1p3; MA-1p4; ML-2p2; MT-2p1; ME-1p2.
	9	Because the eats the iron nail and it will lose its mass	Pilo: MK-1p3; NS-5p3
	4	Its because the heat is the destroyer of particles, meaning that the particles are easily destroyed by heat	Diag:MS-1p2; ML-1p2; MB-3p2; MA-4p2; MQ-1p2
	4	I think the particles would get lost because the heat would have been enough, so they would losen up as particles of gas and disappear	Diag:MZ-1p2
	10	I think so because it would have changed from being solid to liquid, when explains that the form it was	Diag: MZ-1p4

		before let go the particles and turned into another form	
	1	Sun burns the roofing and the colour changes	Diag:MS-2p1
	10	Chemical change as wax has changed its form, to become water because it melts	Diag:NL-1p4
	1	The roof is 'getting old'	Diag:MH-1p1;MS-1p1
	1	Water get cold and turn hard	Pilo:ME-1p1
	3	The water is 'getting hot'	Diag:MH-1p2
	2	Mass of nail decrease because the particles are broken down	Diag:MQ-1p1
	11	Heat destroy the water particles	Pilo:ML-2p4
	7	The sun's 'heat is strong'	Pilo:MA-4p3
	3	Wax melts when there is fire	Pilo:MT-2p2
	2	Mass of nail decrease because the particles are broken down	Diag:MQ-1p1
	9	This is an example of a physical change, because the egg turned to a new product which is no longer the liquid. It is solid egg.	Diag:NL-1p3
	10	Its physical change because when you light it goes down little by little	Diag:NS-4p4
	2	Iron ball shrinks when it gets cooled down	Pilo:NS-5p1
	11	Water molecules will burn	Pilo:NS-5p3
	13	The particles melt faster when combined with heat	Pilo:NS-5p2
	1.1.3	Object which is attracted to the rust	Summ:MS-2
	1.5.1	I thought the egg will be well cooked	Summ:ML-2
	1.5.1	The egg was boiled	Summ:MS-3

	1.1.1	If you put iron out for a long time it will rust	Summ:MM-1
	1.1.3	Chemical change because I see it changing	Summ:MA-4
	1.3.1	Chemical change because I see it changing	Summ:MA-4
		RUSTING (CM)	
		When something rust, its make of water and sun	Cm: MB-1;MM-1
		When a metal stays in water for a long time	Cm:NS-4;MN-3
		The colour it will be brown	Cm:MS-5
		When a metal has been heated, it get rusting	Cm:MA-4
		Powder is formed	Cm:MS-1
		Water causes rust	Cm:NS-1
		Its because of sun and air	Cm:MN-3
		EGG + VINEGAR REACTION	
		The shell disappears	Cm:MQ-1
		Colour changes	Cm:MS-3; MA-2; MM-1; MQ-1; MA-5; ML-2; MS-1; ME-1
		It eats the shell and change colour	Cm:NS-4
		It develops small bubbles	Cm:NS-4; MZ-1;ML-5
		The egg is eaten up by vinegar until it is soft	Cm:NL-1
		Vinegar eats the shell	Cm:MZ-1
		The shell becomes soft	Cm:NS-1
		The shell fall	Cm:MA-4
		The egg shell brakes	Cm:MS-1

		The egg is boiling	Cm:NS-1
		Egg shell is removed	Cm:ML-5
		MAGNESIUM BURNING	
		Light like fireworks	Cm:MZ-1;NL-1.

Key for the respondents:

Diag: MA-1p1- Diagnostic test; Learner code number; page one

Pilo: MA-1p3- Pilot test; learner code number; page 3

Summ: MS-1- Summative test; Learner code number.

Cm: MS-3- Concept maps; learner code number

Wrk 1: MZ-1- Worksheet 1; learner code number

Wrk 2: ML-5- Worksheet 2; learner code number.

Appendix O

ANALYTICAL MEMO 1: CONCEPTS CULMINATING IN CHEMICAL REACTIONS UNDERSTANDING (Collated from pilot test, diagnostic test, learners' class worksheets, summative test, learners' concept maps and reflections and from semi-structured interviews with the focus group)

Table A4: Summary of concepts culminating in chemical reactions understanding: WHAT FORMS OF LEARNING INTERACTIONS ARE DONE BY LEARNERS DURING MEDIATION OF LEARNING? [This will inform Section 5.4 of Chapter 5]

Category	Question number	Learner response	Source of response/data
Atoms as building blocks of matter	6	Atoms are building blocks consisting of molecules which are called particles	Diag:MS-5p3

	7	Because atoms are elements which are called gases	Diag:MQ-1p3
	6	Its because atoms are all the liquids and elements	Diag:MS-1p3
	6	All matter is made up of the smallest building blocks called mixtures, they are everywhere in the food we eat	Diag:MN-2p2
	7	Atoms are made up of elements	Diag:ML-2p2
	6	Atoms are everywhere in the food we eat, they got oxygen that comes from plants	Diag:NL-1p3
Responses linked to change of state	13	Because the particles melt faster when combined with heat	Pilo:MK-1p4
	10	I think so because it would have changed from being solid to liquid, before let go the particles and turned into another form	Diag:MZ-1p4
	10	Chemical change as wax has changed its form, to become water because it melts	Diag:NL-1p4
	7	When something is heated it usually breaks	Diag:ML-5p3

	6	Physical change is when you change solid to liquid	Pilo:MA-4p2
	3	Wax melts when there is fire	Pilo:MT-2p2
	9	This is an example of a physical change, because the egg turned into a new product which is no longer the liquid. It is solid egg.	Diag:NL-1p3
	10	It's a physical change because when you light it goes down little by little	Diag:NS-4p4
	1.2.1	Chemical change because wax change to clear liquid	Diag:MS-3
Responses linked to compounds, elements, mixtures and molecules	14	Molecules expand or get larger	Pilo:MA-1p4
	14	Its because chemical reactions take place when two or more compounds react and form a new substances	Diag:MS-1p5;ML-5p5
	14	The more iron get hot the more molecules expands	Pilo:MT-2p4
	7	We call it an element because because an element is whereby two atoms are mixed together to make a solution or substance	Diag:MS-1p3

	6	All matter is made up of the smallest building block called mixtures, they are everywhere in the food we eat	Diag:MN-2p3
	7	Compound made up of two substances	Diag:MS-2p2
	7	Elements it have only one kind of hydrogen	Diag:MS-3p3
	7	An element because air and materials are other kinds of elements	Diag:NS-1p2
	11	molecules expand	Diag:NS-1p4
	15	Its because chemical reaction is the process of producing reactants	Diag:MS-1p5
	9	This is an example of a physical change, because the egg turned to a new product which is no longer the liquid. It is solid egg.	Diag:NL-1p3
	1.3.2	Chemical reaction because mix some products	Summ:MQ-1
	1.2.2	Chemical change because process of burning has taken place and have formed a new product	Summ:NL-1

Diag: MA-1p1- Diagnostic test; Learner code number; page one

Pilo: MA-1p3- Pilot test; learner code number; page 3

Summ: MQ-1- Summative test; learner code number

Appendix P

ANALYTICAL MEMO 2: INTERPRETING OBSERVATIONS OF PRACTICAL ACTIVITIES (Collated from pilot test, diagnostic test, learners' class worksheets, summative test, learners' concept maps and reflections and from semi-structured interviews with the focus group)

Table A3: Summary of learner observations of practical activities: WHAT FORMS OF LEARNING INTERACTIONS ARE DONE BY LEARNERS DURING PRACTICAL ACTIVITIES? [This will inform Section 5.3 of Chapter 5]

Category	Question number	Learner responses	Source of response/data

Responses due to learner observations of practical activities	1.1	When you burn magnesium it will become ashes	Wrk 1:MN-1;ML-1;MN-2;MB-2;ML-2:ML-3
	2.1	I think it will be black	Wrk 1:MM-1;MS-5
	2.1	It will change colour	Wrk 1:MA-2;MB-1;MS-1;MN-2;MB-2;ML-5;NS-3
	2.1	The magnesium ribbon will turn black	Wrk 1:MS-2;ML-2
	2.1	It will burn	Wrk 1:MS-6;ML-2;MS-3;MA-4;MT-2;MN-3;MY-1;MQ-1;NS-1;NA-2;NS-2;NL-1;NS-5.
	2.3	Ashes	Wrk 1:MS-1;MZ-1;MS-2;MB-2;ML-2;ML-3:ML-5;MS-5;MA-4;MT-2;ME-1;MA-5;MY-1;MQ-1;NS-1;NA-2;NS-2;NS-3;NL-1;NS-5;NB-1.
	2.3	The products that are formed are the ashes	Wrk 1:ML-5;ME-1
	1a	I have observe bubbles.	Wrk 2:MA-1;MK-1:MA-1:MA-2:MP-1;MB-1;MS-1;MN-2;MH-1;ML-2;ML-3:Ms-3;MM-1;MB-3;MS-4;ML-5;MS-5;MA-4;MS-6;MT-2;ME-1;MN-3;MA-5;MY-1;NA-1;NA-2;NS-2;NS-3:NL-1;NS-4;NB-1;NA-3.
	1a	Change colour	Wrk 2:ML-1;MS-2;ML-5.
	1a	Egg getting bigger	Wrk 2:MS-5
	1c	Egg breaks down	Wrk 2:MA-2
	2a	I observe bubbles	Wrk 2:MA-1;MK-1;MA-2;MP-1;MB-1;MS-1;MN-

			2;MB-2;MH-1:MH-2;ML-2;MS-3;MM-1;MB-3;MS-4;MS-6;MT-2:ME-1;MN-3;MA-5;MY-1;NA-1NA-2;NS-2;NS-3;NL-1;NS-4;NB-1.
	2a	It starts to boiling	Wrk 2:MB-2;MA-4;NA-3.
	2d(i)	Bubbles formed	Wrk 2:MA-1;MA-2;MP-1;MB-1;MS-1;ML-1;MN-2;MB-2;MH-1;ML-2;ML-3;MS-3;MM-1;MB-3;MS-4;ML-5:MS-5;MA-4;MT-2;ME-1;MN-3;MA-5;MY-1;NA-1;NA-2;NS-3;NL-1;NS-4;NB-1.
	2d(ii)	Colour change	Wrk 2:MP-1;MS-1;ML-1;MN-2;MB-2;MH-1;ML-2;ML-3;MS-3;MM-1;MB-3;MS-4:ML-5:MS-5:MA-4;MS-6;MT-2;ME-1;MN-3;MA-5;MY-1;NA-2;NS-3;NL-2;NS-4;NB-1.
	2d(iii)	Heat is produced	Wrk 2:MS-1;ML-1;MS-2;MH-1:ML-2;ML-3:MM-1;MB-3;MS-4;ML-5;MS-5;MA-4;MT-2;ME-1;MA-5;MY-1;NA-2;NA-3;NL-1;NS-4;NB-1.
	1(i)	Changing the colour	Wrk 3:MA-1;MA-2;MP-1;MN-1:MB-1;MS-1;MZ-1ML-1:MN-2;MB-2:MH-1;ML-2:MS-3:MM-1;MB-3:MS-4;ML-5:MS-5:MA-

			4:MS-6:MT-2:ME-1;MN-3;MA-5:MY-1;MQ-1:NL-1:NS-4:NS-5:NB-1:NA-3:NS-3:NS-2:NA-2
	1(ii)	Colour change	Wrk 3:MS-3;MS-4;MN-3;NA-3;NS-3;MN-3;MY-1;MQ-1;NL-1;NS-4;NS-5;NS-2
	1(ii)	A chemical reaction has taken place	Wrk 3:MA-1;MB-1;MS-1;MZ-1;MA-1;MS-2;ML-2;ML-5;MS-5;MA;4MT;2ME-1.
	2(i)	It changes the colour	Wrk 3:MA-2;MP-1;MB-1;MS-1;MZ-1;ML-1;MN-2;MB-2;ML-2;MS-3;MM-1;MB-3;MS-4;ML-5;MS-5;MA-4;MS-6;MT-2;ME-1;MN-3;MA-5;MY-1;MQ-1;NS-4;NS-5;NB-1;NA-3;NS-2.
	2(i)	A chemical reaction has taken place	Wrk 3:MA-1;MS-2;MN-1;MZ-1;MH-1;MN-3;NL-1;NS-4;NS-2;NA-2.
	2(ii)	Brown colour (tea)	Wrk 3:MA-1;MP-1;MS-1;MN-1;MZ-1;MS-2;MH-1;ML-2;MS-4;ML-5;MS-5;MA-4;ME-1;MN-3;MY-1;MQ-1;NL-1;NS-4;NB-1;NA-3;NS-3.
	2(iii)	Black tea is the indicator	Wrk 3:MA-1;MP-1;MS-1;MN-1;MZ-1;MS-2;MH-1ML-2;MS-4;ML-5;MS-5;MA-4;ME-1;MN-3;MY-

			1;MQ-1;NL-1;NS-4;NB-1;NA-3;NS-3.
	2(v)	Chemical reaction	Wrk 3:MS-1;MZ-1;MS-2;ML-2;NL-1;NS-4;NS-5
	2(v)	It changes colour	Wrk 3:MA-2;MP-1;MB-1;MM-1;MS-4;MS-5;MA-4;MT-2;ME-1;MN-3;NS-4.
	1.2.2	Chemical change because there was a new substance formed	Summ: MS-1
	1.3.2	Chemical changes because bubbles are formed	Summ:MS-1
	1.7.3	Magnesium 'appears' like fireworks and ashes are formed	Summ:MS-1
	1.1.3	It is a chemical change because it changes colour	Summ:ML-2
	1.1.3	Chemical changes because I can see it changing	Summ:MA-4
	1.3.1	Chemical changes because I can see it changing	Summ:MA-4
	1.7.1	It gets bigger while it is burning and it changes into another product	Summ:MA-4
	1.2.2	Chemical change because process of burning has taken place and have now formed a new product	Summ:NL-1
		REFLECTIONS IN CM	
		Practical activities are so easy, they tell us what to do and it is so easy. I enjoyed it	Refl**:** MA-1; MQ-1

		Practical help us develop more knowledge	Refl:MS-5
		Flashing back the things I have learnt about in the experiment	Refl:MS-1
		The colour will be brown	Refl:MA-5
		CO_2 + Limewater reactions	
		Colour change	Refl:ME-1;MS-2;MA-4;MS-5;Ml-2;NS-4;MQ-1
		Colour change it turns milky	Refl:MA-1
		EGG AND VINEGAR REACTION	
		Igandaliyatshinshaikhalalibe mhlope	Cm: MA-1
		The shell disappears	Cm:MQ-1
		Colour changes	Cm:MS-3; MA-2; MM-1; MQ-1; MA-5; ML-2; MS-1; ME-1
		It eats the shell and change colour	Cm:NS-4
		It develops small bubbles	Cm:NS-4; MZ-1;ML-5
		The egg is eaten up by vinegar until it is soft	Cm:NL-1
		Vinegar eats the shell	Cm:MZ-1
		The shell becomes soft	Cm:NS-1
		The shell fall	Cm:MA-4
		The egg shell brakes	Cm:MS-1
		The egg is boiling	Cm:NS-1
		Egg shell is removed	Cm:ML-5
		LEMON TEA MAKING	
		Change colour	Cm:ME-1;NA-2;MS-1;MZ-1;MA-4;MS-5;MT-2;NS-

			4;MQ-1;MA-1;MA-2;MS-2;ML-5NS-5.
		Smell lemon	Cm:MZ-1;NS-4;ML-5
		Black tea changes colour to brown	Cm:NL-1
		New substance formed	Cm:MS-1
		MAGNESIUM BURNING	
		Ashes are formed	Cm: NS-1; MZ-1;MA-4; MS-5
		Light like fireworks	Cm:MZ-1;MA-4;MS-5
		Burns into ashes	Cm:NL-1;NS-4;ML-5
		It burns	Cm:NA-2; MT-2
		Light affects your naked eyes	Cm:MS-5; MQ-1
		$CACO_3$ + HCL REACTION	
		Bubbles	Cm: MT-2;MA-4
		Colour change	Cm:MT-2; ML-2;MA-4

Key for the respondents:

Summ: MS-1- Summative test; Learner code number.

Cm: MS-3- Concept maps; learner code number

Refl: MA-1- Reflections, learner code number

Wrk 1: MZ-1- Worksheet 1; learner code number

Wrk 2: ML-5- Worksheet 2; learner code number.

Wrk 3: MS-2- Worksheet 3; learner code number.

Appendix Q

ANALYTICAL MEMO 3: CONCEPTUAL GRASP OF CHEMICAL REACTIONS (Collated from pilot test, diagnostic test, learners' class worksheets, summative test, learners' concept maps and reflections and from semi-structured interviews with the focus group)

Table A5: Summary of conceptual grasp of chemical reactions: WHAT FORMS OF LEARNING INTERACTIONS ARE DONE BY LEARNERS TO REFLECT CONCEPTUAL GRASP OF CHEMICAL REACTIONS? [This will inform Section 5.5 of Chapter 5]

Category	Question number	Learner response	Source of response/data
Evidence of chemical reactions	14	Its because chemical reaction take place when two or more compounds react and form out new substances	Diag:MS-1p5;ML-5p5
	15	Its because chemical reaction is the process of producing reactants	Diag:MS-1p5
	14	When you mix two things you are making chemical reaction	Diag:NS-4p5
	2(iii)	Black tea is the indicator	Wrk 3:MA-1;MP-1;MS-1;MN-1;MZ-1;MS-2;MH-1ML-2;MS-4;ML-5;MS-5;MA-4;ME-1;MN-3;MY-1;MQ-1;NL-1;NS-4;NB-1;NA-3;NS-3.
	2(v)	Chemical reaction	Wrk 3:MS-1;MZ-1;MS-2;ML-2;NL-1;NS-4;NS-5
	1.3.2	Chemical reaction because mix some products	Summ:MQ-1
	1.1.3	It is a chemical change because it changes colour	Summ:ML-2

	1.2.1	Chemical change you form two substances	Summ:ML-2
	1.3.1	Chemical change because it form bubbles	Summ:ML-2;MS-4;MS-5
	1.3.2	When two substances are mixed	Summ:ML-2
	1.2.1	Chemical change because wax change to clear liquid	Summ:MS-5
	1.1.3	Chemical change because the colour change	Summ:ML-3
	1.1.3	Chemical change because I can see it changing	Summ:MA-4
	1.3.1	Chemical change because I can see it change	Summ:MA-4
	1.3.2	Chemical change because mix some products	Summ:MQ-1
	1.2.2	Chemical change because the process of burning has taken place and have now formed a new product	Summ:NL-1
		RUSTING (CM)	
		Metal changes colour	Cm:NL-1;MT-2;ML-2;MA-4;MS-

			2;MZ-1;MS-1;NA-2;ME-1;NS-1;NS-5;ML-5
		Breaks easily	Cm:MS-5
		Powder is formed	Cm:MS-1
		BLOWING THROUGH LIMEWATER	
		Colour change	Cm:ME-1;MS-2;MA-4;MS-5;ML-2;NS-4;MQ-1;MS-3;MA-2;MM-1;MQ-1;MA-5;ML-2;MS-1
		Changes its colour into complete white	Cm:ML-5
		More bubbles are formed	Cm:MS-1
		Carbon dioxide is added	Cm:NS-1
		Colour changes it turns to milky	Cm;MA-1
		MAKING LEMON TEA	
		Change colour	Cm:ME-1;NA-2;MS-1;MZ-1;MA-4;MS-5;MT-2;NS-4;MQ-1;MA-1;MA-2;MS-2;ML-5NS-5.
		Smell lemon	Cm:MZ-1;NS-4;ML-5

		Black tea changes colour to brown	Cm:NL-1
		New substance formed	Cm:MS-1
		MAGNESIUM BURNING-CM	
		Ashes are formed	Cm: NS-1; MZ-1;MA-4; MS-5
		Light like fireworks	Cm:MZ-1;MA-4;MS-5
		Burns into ashes	Cm:NL-1;NS-4;ML-5
		It burns	Cm:NA-2; MT-2
		$CACO_3$ + HCL	
		Bubbles	Cm: MT-2;MA-4
		Colour change	CmMT-2; ML-2;MA-4
Responses linked to reactants and products.	15	Its because chemical reaction is the process of producing reactants	Diag:MS-1p5
	9	This is an example of a physical change, because the egg turned to a new product which is no longer the liquid. It is solid egg.	Diag:NL-1p3
	1.3.2	Chemical reaction because mix some products	Summ:MQ-1

	1.2.2	Chemical change because process of burning has taken place and have formed a new product	Summ:NL-1
Responses linked to the use of familiar responses.		I prefer to learn with familiar resources because I understand it better	Refl: MA-4
		Learners should work with objects they know	Refl:MS-5
		When I don't see the really things that we learn about	Refl:NS-5
		I see them every day and I use them every day… the understanding would be more perfect…	Refl:MZ-1

Key for the respondents:

Diag: MS-1p5- Diagnostic test; Learner code number; page five

Wrk 3: MZ-1- Worksheet 3; learner code number

Summ: MS-1- Summative test; Learner code number.

Cm: MS-3- Concept maps; learner code number

Refl: MZ-1- Reflections; learner code number.

Appendix R

<u>UNIT OF WORK FOR TEACHING CHEMICAL REACTIONS</u>

<u>GRADE</u>: 8

<u>INTRODUCTION TO CHEMICAL REACTIONS.</u>

1. **What are chemicals?**

Every substance in the world is made up of chemicals. The sea, land, plants, animals, air and even our bodies are all made up of chemicals.

Chemicals are made up of atoms, elements, compounds and mixtures.

Many substances in the world change. For example; lakes freeze in winter, sugar dissolves in a cup of tea, and water evaporates from a dam, coal burns in a fire, burning bread in a toaster, boiling of water on a stove, warming wax and so on.

Q. Can you give your own examples?

Some changes are called chemical changes and some are not.

Q How can we tell the difference?

2. **Chemical and physical change**

There are different ways to spot a chemical change, but there is only one thing that MUST happen during every chemical change.

A chemical change takes place when new substances are made that are different from the substances that we started with.

Heating candle wax in an empty tin.

- What do you observe?
- Is the product really new? Why?

A change where no new substance is formed is called a ***PHYSICAL CHANGE*** and in a ***CHEMICAL CHANGE*** a new substance is formed.

Q. State 3 differences between a physical and a chemical change?

3. **Atoms**

Everything around us is made up of vey tiny particles called *atoms.* These atoms can mix together to form mixtures, or they can join together to form bigger substances.

Atoms join together in a chemical reaction. We call this process *bonding.* Atoms joined together form elements and compounds.

4. Elements and Compounds

They are many substances in the world. Yet everything in the universe is made up from about 100 basic chemicals, called elements.

- Some substances, like gold contain just one element. Others contain two or more elements joined together.
- These combined elements are called *compounds.*
  Water is a compound made up of two elements called oxygen and hydrogen.
- *Elements:* An element is a matter which consists of only one atom. Gold, silver, hydrogen and oxygen are all examples of elements.
- *Molecule:* Is a particle containing two or more atoms joined together. Some molecules are quite small, for example, water molecule is made up of one oxygen atom and two hydrogen atoms.

Inside a compound, they are forces that hold the atoms together. These forces are called *bonds.*

5. Bond making and breaking

In a chemical reaction, the bonds in the reactants break and new bonds form when the product are made. This cause a chemical change. This means that the products have completely new and different properties to the reactants because a new substance has formed.

6. Chemical reaction

Chemical reactions take place in the world around us all the time, some natural and others man-made. Sometimes there may be just two elements or compounds involved. But whenever a reaction takes place, at least one of the elements or compounds is changed, and new compounds are formed.

Q. Can you give three examples of reactions that are occurring naturally? Two examples have been given for you.

Natural chemical reactions:

(a) Trees' leaves decaying. (b) Ripening of fruits.
(b) --
(c) --
(d) --

Man-made reactions

Every substance in the world is made up of chemicals. The sea, land, plants, animals, air and even our bodies are all made up of chemicals. Sunlight liquid and Maq are examples of chemicals for dish washing in the kitchen.

Give 4 specific examples of chemicals you are familiar with.

(a) --

(b) --

© --

(e)--

PRACTICAL ACTIVITY: 1

Topics: Oxidation of iron and magnesium

Lesson objectives:

Make predictions (in the case of magnesium burning)

State observations of the reactions.

Explain the observations.

Identify reactants and products in the reactions.

Share group observations (Test sense-making).

Materials used:

Familiar resources: Heavily oxidised mathematical set casings and new mathematical set casings for comparison.

Specialist resources: Magnesium.

Introduction: I introduced the topic by asking learners about what they were observing of the two sets of mathematical casings. This was to get an idea of the prior knowledge learners are bringing to the classroom.

- I asked learners for explicit reasons on the differences and went on to discuss about rusting. What is it?
- Effects of rusting and how it can be curbed was discussed.

Activity: Burning magnesium ribbon in a flame. *Caution:* Do not look directly into the magnesium flame as it burns. It hurts your eyes.

Place magnesium ribbon onto the flame of a burning candle.

1. What do you predict will happen if you place magnesium ribbon on the candle flame? -----
----
----

2. What do you think are the **reactants** involved? (The substances that react with each other are called reactants and the new substances that form during a chemical reaction are called products). --

3. And what **products** are formed? ---

5. Can you explain why the change takes place? ---

---.

Exercise

1. Copy and complete the following sentences about chemical reactions. Use the words: *products and reactants only*.

In a chemical reaction, the substances that are produced are called the --------------------------- of the reaction.

In a chemical reaction, the substances that react with one another are called the -----------------

Substances can react with each other to form -------------------- with different chemical properties.

In reactions, re-arrangement of the atoms takes place, to form ------------------------------

2. Complete the table below by filling in the reactants and products of the given chemical reactions:

Chemical reactions	Reactants	Products
Burning candle wax		
Rusting of iron		
Burning wood		
Photosynthesis		

Elements can join together to form compounds. This is also called chemical reactions. During a chemical reaction, substances react to form completely new and different substances, which have different properties to the substances that reacted together.

The substances that react with each other are called *reactants.* The new substances that form during a chemical reaction are called the *products.*

7. Products and reactants

Any new substance produced during a chemical change is called a **product** of the change. The substances we start with are called **reactants.**

One way to work out if the products are really new or not is to ask yourself the question 'Can I get the starting materials back again?' If you can, then nothing new has been made.

- If the physical change happens, the process of adding heat energy is called ***heating.*** The substance do not react with the air or the oxygen.
- Adding heat energy can also cause chemical changes. The process is called ***burning*** or combustion, and sometimes energy is released in the form of light/or heat energy.

8. A substance is only changed by a chemical reaction- there is a chemical change

Investigation a chemical reactions

PRACTICAL ACTIVITY: 2

Topics: Egg/Vinegar reaction and Calcium carbonate/Hydrochloric acid reaction.

Lesson objectives:

State observations of the reactions.

Explain the observations.

Identify reactants and products in the reactions.

Share group observations (Test sense-making. Do the groups get the same results?).

Materials used:

Familiar resources: Eggs and Vinegar.

Specialist resources: Calcium carbonate (Caco$_3$), Hydrochloric acid, Beakers and test tubes.

Introduction: I introduced the topic by asking learners about examples of chemical reactions. This was to get an idea of the prior knowledge learners are bringing to the classroom.

Activity 1: The researcher and learners placed an egg in the beaker with vinegar. The egg was 2/3 covered with vinegar and left over the weekend. Observations were done the following Monday, in groups.

Method:

(c) Place your egg shells carefully into the beaker.
(d) Pour the vinegar over the egg shells.

Observations/Results: Learners were asked to answer the following questions in groups:

(g) Can you see anything happening? Describe your observations.
(h) Explain your observations. Why did this happen.
(i) Groups sharing observations, reactants and products.

Activity 2: Lesson continued.

I instructed learners to drop few drops of diluted hydrochloric acid to calcium carbonate in test tube.

Method:

(a) Place calcium carbonate chips into a test tube.

(b) Pour the hydrochloric acid carefully into the test tube with calcium carbonate.

Observations: Learners were asked to answer the following questions in groups:

(g) Can you see anything happening? Describe your observations.

(h) Explain your observations. Why did this happen.
(i) Groups sharing of observations, reactants and products.

To conclude the lesson, learners were given worksheets to complete. The written activities were given to determine their understanding of the topic and to check the impact of everyday chemical change by giving another example- specialist chemical change example.

PRACTICAL ACTIVITY: 3

Topics: Making lemon tea and blowing with a straw through clear limewater.

Lesson objectives:

State observations of the reactions.

Explain the observations.

Identify reactants and products in the reactions.

Share group observations (Test sense-making. Do the groups get the same results?).

Materials used:

Familiar resources: Lemon (acid) and Black tea (indicator).

Specialist resources: Limewater and test tubes.

Introduction: I introduced the topic by asking learners about examples of chemical reactions. This was to get an idea of the prior knowledge learners are bringing to the classroom.

Activity 1: Making lemon tea.

I brought prepared black tea and poured it into two 100ml beakers. Each group was given two beakers with black tea. Each group was given cut lemons and were asked to squeeze lemon juice into one of the beakers with black tea. Then, learners were asked to compare colour of tea in the two beakers. Learners were asked to share observations in order to learn from one another.

Observations/Results: Learners were asked to answer the following questions in groups:

(j) Can you see anything happening? Describe your observations.
(k) Explain your observations. Why did this happen.

(l) Groups sharing observations, reactants and products.

<u>Activity 2:</u> Blowing through the clear limewater.

I gave learners each a plastic drinking straw and test tube with limewater. I instructed each to blow through the clear limewater and observe colour changes. Learners were asked to share observations and to draw them.

<u>Observations:</u> Learners were asked to answer the following questions in groups:

(j) Can you see anything happening? Describe your observations.
(k) Explain your observations. Why did this happen.
(l) Groups sharing of observations, reactants and products.

To conclude the lesson, learners were given worksheets to complete. The written activities were given to determine their understanding of the topic and to check the impact of everyday chemical change by giving another example- specialist chemical change example.

<u>SUMMARY</u>

You can tell if a chemical reaction is taking place by looking for the following signs:

- A colour change
- Bubbles of fizzing
- It feels hot or cold
- A smell.