

An investigation of how Natural Sciences teachers mediate
learning of chemical reactions in Grade 9:

A case study

Thesis submitted in partial fulfilment of the requirements for the degree of

MASTER OF EDUCATION

(SCIENCE EDUCATION)

OF

RHODES UNIVERSITY

By

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December, 2011

DECLARATION

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

Signature: Date:.....

ABSTRACT

This research study involves two Grade 9 Natural Sciences teachers from two schools in the Lady Frere District of the Eastern Cape. The reason for selecting these two teachers is that in 2009 they, like me, obtained an Advanced Certificate in Education (Science and Maths) from Rhodes University. As a result, we have a good working relationship. Furthermore, both teachers are actively involved in the Natural Sciences curriculum in the District and their schools are not far from the District Office where I work.

The principal objective of this study was to investigate how Natural Sciences teachers mediated learning in order to enhance conceptual development and understanding of chemical reactions in Grade 9. It was triggered by the transformation in curriculum in South Africa as well as by my experience of working with Natural Sciences teachers in our rural district.

The study is informed by an interpretive paradigm using a qualitative case study approach. The data was gathered by administering analysis of documents, semi-structured interviews, observations, field notes and journals. During the data analysis process, patterns and themes were illuminated using the inductive analysis method. Rich data sets in relation to the main research question on how Natural Sciences teachers mediated learning in order to enhance conceptual development and understanding of chemical reactions in Grade 9 emerged from the analysed data.

The conclusions that can be drawn from the study indicate that when teaching chemical reactions, teachers should have adequate content knowledge as well as pedagogical content knowledge. It is thus recommended that teachers consider the prior knowledge of learners, use a variety of teaching and learning approaches including practical activities, to make learning meaningful.

The major limitation of this study is that the two selected teachers do not represent the whole population of Grade 9 teachers in the Lady Frere District. Therefore, the findings cannot be generalized to represent the larger population. It is recognised, however, that within the qualitative inquiry, reliability and generalizability play a minor role.

ACKNOWLEDGEMENTS

My achievements in the study have been made possible by the involvement of my work colleagues, co-students, my family and friends.

I thank the Lord our Saviour for instilling the thought in Dr KM Ngcoza's mind to approach me about doing a Master's Degree. A word of gratitude goes to my supervisor, Dr KM Ngcoza, a prominent community developer, for being there all the way and for encouraging me when the going was getting tough. Thanks a lot *Gxarha* for your patience and the extra mile you took so that I could achieve my goals.

Thank you to my research participants who worked tirelessly with me from beginning to end. They were so keen to cooperate even during difficult times of examinations and moderations. Through working together on this research project, we have thus developed very good working relations.

I am grateful to my mother Olga Nondumiso Klaas, for the prayers and motivation offered to me. You were always there for me encouraging me in one way or the other. Checking on me from time to time whenever I attended sessions at Rhodes University and the undying love you always give made me fly higher and higher. Thanks a lot *MaMbongwe* for taking care of me from birth until now.

To my children, Tandokazi, ZamaQwathi, Ongeziwe and my grandchild Luphiwe Oyintando ka Thixo for being inspirational and patient when I left you alone during contact sessions and you remained holding the fort.

Many thanks to my co-students Zukiswa and Gerald for the support you gave me. You were the source of fuel that gave me strength to finish the race.

In undertaking this academic research I benefited from generous funding from the Department of Basic Education in the Eastern Cape Province. I thank you for that!

Last but not least, I would like to extend my sincere words of gratitude to Ms Carol Leff for editing my thesis. God bless you!

DEDICATION

This thesis is dedicated to my mother (Olga Nondumiso Klaas), my three children (Tandokazi, ZamaQwathi and Ongeziwe) and my grandson (Oyintando).

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LIST OF ABBREVIATIONS AND ACRONYMS

ACE	Advanced Certificate in Education
ASs	Assessment Standards
CAPS	Curriculum and Assessment Policy Systems
CASS	Continuous Assessment
DoE	Department of Education
HL	Home Language
HOD	Head of Department
IP	Intermediate Phase
IQMS	Integrated Quality Management Systems
L	Learner
LOs	Learning Outcomes
LoLT	Language of Learning and Teaching
NCS	National Curriculum Statement
NS	Natural Sciences
OBE	Outcomes Based Education
PCK	Pedagogical Content Knowledge
Q	Question
RPL	Recognition of Prior Knowledge
S	School
SP	Senior Phase
STD	Senior Teachers' Diploma
T	Teacher
TIMMS	Trends in International Mathematics and Science Study
ZPD	Zone of Proximal Development

Chapter One

An orientation to the study

1.1 Introduction

This chapter provides the introductory background and context of the study. It also focuses on the significance of the study, the aims and objectives, the problem statement and the research questions. Finally, I provide a brief overview of the chapters in my thesis.

1.2 Background to the study

As a result of the learners' poor performance in certain learning areas, the Department of Education (DoE) Quality Promotions Section embarked on a strategy to address the problem. In October 2009, the Quality Promotion Section assessed Grade 9 learners in English, Mathematics and Natural Sciences. Schools were sampled and in my District five schools wrote the assessment tasks which were externally set and marked. Fortunately, I was one of the markers and we found that learner performance was very disappointing to say the least.

Again in June 2010, the DoE felt that having a common assessment task in all the exit grades could improve the situation. It was then decided that Grades 3, 6 and 9 should be assessed in all the learning areas. Subject Advisors responsible for the different learning areas were asked to develop assessment tasks and submit them to the Provincial coordinators for moderation. Educators were then selected to assist the Subject Advisors and the final assessment was done in June 2010.

The examination timetable was the same across the Province. Marking was done by the respective teachers and the Subject Advisors were requested to analyse the results at the end. I analysed the Grade 6 and 9 Natural Sciences results and discovered that the performance in Grade 6 was commendable but in Grade 9 it was a disaster. In my view there are various factors that could be associated with this, for example:

- Because of the language which is a barrier for the majority of learners, they were unable to answer questions that had verbs such as describe, explain and discuss;
- Inability of learners to answer multiple choice questions; and

- Seriously limited and distorted conception of chemistry and physics-related concepts.

This prompted me to further analyse the Grade 9 results looking at the performance in each question and strand. From the analysis, I found out that learners were challenged by the strand **Matter and Materials** which comprises mostly of chemistry in Grade 9. I then assumed that this could be due to the strategies that the Natural Sciences teachers might be using to mediate learning of chemistry, in particular, chemical reactions.

The concept of chemical reaction has been found by teachers and researchers to be particularly difficult for learners and may well be one of the sources of the alternative conceptions they hold (Boo, 1998; Hesse & Anderson, 1992). Hesse and Anderson (1992) attributed the difficulty that learners encounter with chemical reactions and changes, and their misconceptions, to the learners' learning styles as well as to the teaching methods of the teachers.

It is thus imperative for teachers to be conversant with regard to the content (scope) to be taught in each topic as well as the pedagogy (method) of presenting that content, for effective learning to take place. Knowledge of content to be taught as well as the method of presenting it is known as pedagogical content knowledge (PCK) (Section 2.2.2).

In my view, establishing and maintaining a learning environment that is conducive to learning is a priority for science teachers. However, this is easier said than done. To begin with, traditional teaching practices are sometimes difficult to discard. Teachers might commence a lesson with good intentions only to find that they forget to follow their game plan. It is clear from most research studies that sustained change can take a long time to establish.

It is recognised that while some teachers are committed to the new approaches of teaching that are learner-centred, they are however still frustrated by their inability to get all of their learners to accept their styles of teaching. Thus, learners might also have difficulty adapting to an environment in which they are given the responsibility for making sense of science as it is required by the new curriculum in South Africa. Understandably so, they too have experienced traditional practices in which they were force-fed a diet of factual information to be rote learned. Hence they believe teachers should be experts whose role it is to transmit the knowledge to them. If teachers do not fulfil their traditional roles as expected by their learners, learners might be confused and have difficulty in engaging as intended by the teachers.

These tensions have triggered my interest in investigating how Natural Sciences teachers mediate the learning of chemical reactions. How are chemical reactions presented in the textbooks used by teachers and how do teachers make sense of such content knowledge when planning lessons? How do they integrate learners' background information? How do they utilize practical activities and concrete objects when teaching abstract concepts to enhance meaningful learning?

1.3 Significance of the study

The study seeks to find out how teachers mediate learning when teaching chemical reactions in order to enhance learners' conceptual development and understanding. Essentially, it sought to establish what challenges Natural Sciences teachers encounter when preparing and presenting lessons on chemical reactions.

The potential value of this study is that if teachers can ensure that learners get the basics of chemistry, then learners would be in a better position to improve their performance and love for the subject even at higher levels of their studies.

1.4 Research sites and participants

This research study comprises of two Grade 9 Natural Sciences teachers from two schools in the Lady Frere District. The reason for purposively selecting these two teachers is that in 2009 we all obtained an Advanced Certificate in Education (ACE) (Science and Maths) from Rhodes University and as a result, we have good working relations. Furthermore, both teachers are actively involved in the Natural Sciences curriculum activities in the district and their schools are not far from the District Office where I work.

1.5 Goal of the study

The main goal of this study was to investigate how Natural Sciences teachers mediate learning when they teach chemical reactions in Grade 9 with a view to enhance conceptual development and conceptual understanding.

1.6 Research questions

To realize the goal, the following question and sub-questions were posed:

- **How do Natural Sciences teachers mediate learning in order to enhance conceptual development and understanding of chemical reactions in Grade 9?**
 - How do Natural Sciences teachers activate background knowledge related to chemical reactions in Grade 9?
 - What basic concepts do Grade 9 learners need to know in order to understand chemical reactions?
 - Which concepts related to chemical reactions do Grade 9 learners and Natural Sciences teachers find challenging?
 - How can Natural Sciences teachers improve the teaching of chemical reactions in Grade 9?

1.7 Outline of the thesis

The thesis consists of five chapters and its structure has been arranged as follows:

Chapter One: An orientation to the study

This is the introductory chapter which informs the reader what is to follow in the study. It discusses the background and context of the study, the significance of the study and why the topic has been chosen. This chapter also gives the aims, objectives, as well as research questions to be discussed in the research.

Chapter Two: Literature review

This chapter deals with the review of relevant literature to this study. The theoretical framework informing the study is discussed. It also compares and contrasts the views of other authors on teaching and learning of chemical reactions.

Chapter Three: Research methodology

This chapter describes the research design, the methodology and the paradigm adopted in this study. The research site, participants and the variety of data gathering techniques are discussed. Also, validity and ethical considerations are explored.

Chapter Four: Presentation of primary findings

Chapter four focuses on the results and findings, including a description of findings of the procedures and processes used to gather data. In this chapter the primary findings are presented in detail.

Chapter Five: Interpretation, discussion of findings and recommendations

This chapter deals with the interpretation and discussion of the findings against a backdrop of a literature review. It presents a summative outcome of the study. It also presents recommendations, limitations as well as suggesting future areas for further research on this topic.

1.8 Concluding remarks

In this chapter I have presented a road map for the reader based on the conceptualisation of my study. I did this by providing a brief background of the problem statement in relation to my study, followed by the significance and goals of the study.

In the next chapter the literature relevant to my study is critically reviewed in relation to the goal and research questions of this study.

Chapter Two

Literature Review

2.1 Introduction

This chapter seeks to review literature on a number of issues concerning the manner in which the Grade 9 Natural Sciences teachers mediate learning in order to enhance learners' conceptual development and understanding of chemical reactions.

The first part of this chapter looks at what literature says about the theoretical framework underpinning this study, specifically, constructivism (cognitive constructivism and social constructivism) as well as Shulman's (1986/1987) pedagogical content knowledge (PCK). The theoretical framework is used as an analytical tool in this study.

In addition, the role of prior knowledge which includes the concepts that learners are expected to know before learning chemical reactions is highlighted.

Also, the suggested teaching and learning strategies from the literature point of view are critically analysed in order to equip teachers with invaluable information to teach effectively and efficiently so as to achieve better results at the end of each teaching and learning practices. Finally, the role of practical activities, its advantages and limitations as well as planning for a good practical activity are explored in this chapter.

2.2 Theoretical Framework

This study is informed by the theoretical framework of constructivism, in particular, cognitive and social constructivism as well pedagogical content knowledge.

2.2.1 Constructivism

Constructivism is a theory of knowledge which argues that humans generate knowledge and meaning from their experiences. Peers, Diezmann and Waters (2003) highlight that constructivism has been a major influence on science education since the 1980s. They also point out that constructivist theories propose that individuals build understandings through the active construction of meaning based on their prior knowledge and experiences. The driving force of

constructivism is that teachers should facilitate learners' learning processes by creating conducive environments for learners to construct their own knowledge.

The Outcome Based Education (OBE) Curriculum 2005 for the Natural Sciences is based on constructivism in that the teacher is expected to guide the learners in such a way that they are able to construct their own knowledge based on their direct experiences within and outside the school environments. In this regard, the knowledge they eventually construct would be the result of a variety of interactions, for example, peers, classmates, teachers, parents, *et cetera* (Natural Sciences Policy Document, 2002).

Tovani (2004: 90) points out that small-group instruction “stimulates higher levels of thinking, encourages articulation of thinking, helps students remember, allows students to make connections and see different perspectives, as well as promotes deeper understanding.” It is this deeper level of understanding that we believe must be promoted via changes in teaching strategies such as cooperative learning, science discourses, practical activities and many more.

Furthermore, Fennimore and Tinzmann (1990) too, identify a difference between a behaviorally oriented curriculum in which knowledge and skills are taught individually and then connected as opposed to a constructivist-oriented curriculum in which students acquire knowledge and skills while carrying out tasks that require higher-order thinking. Constructivist curricula should thus be developed in such a way that students are required to expand and develop prior knowledge by connecting it to new learning (Huitt, 2003).

In this study I will focus on *cognitive* and *social constructivism*. The relationship between cognitive constructivism and social constructivism is explained by Maxim (2006: 339) in the following way:

Cognitive constructivists and *social constructivists* have much in common, but they differ noticeably in one key area—the extent and type of involvement of both students and teachers. Although each model requires effort and responsibility on the part of both, *social constructivists* stress the organization of “communities of learners” in which “more expert” adults or peers provide assistance to the less skilled learners. *Cognitive constructivists*, on the other hand, describe a learner-centered environment where the making of knowledge is carried out by individual learners in a fashion that supports their interests and needs. For *cognitive constructivists*, learning is primarily an individualistic venture.

Cognitive constructivism

As opposed to the social constructivist perspective that describes the mind as a distributed entity that extends beyond the bounds of the body into the social environment, cognitive constructivists describe the mind in terms of the individual, restricting its domain to the individual's head.

Formalization of the theory of cognitive constructivism is generally attributed to Jean Piaget, (1985) who articulated mechanisms by which knowledge is internalized by learners. He suggested that through processes of *accommodation* and *assimilation*, individuals construct new knowledge from their experiences. When individuals assimilate, they incorporate the new experience into an already existing framework without changing that framework. This may occur when individuals' experiences are aligned with their internal representations of the world, but may also occur as a failure to change a faulty understanding; for example, they may not notice events, may misunderstand input from others, or may decide that an event is a fluke and is therefore unimportant as information about the world.

In contrast, when individuals' experiences contradict their internal representations, they may change their perceptions of the experiences to fit their internal representations. According to the theory, accommodation is the process of reframing one's mental representation of the external world to fit new experiences. Accommodation can be understood as the mechanism by which failure leads to learning: when we act on the expectation that the world operates in one way and it violates our expectations, we often fail, but by accommodating this new experience and reframing our model of the way the world works, we learn from the experience of failure, or others' failure process (Wertsch, 1997).

One important generalization of Piagetian theory is the role of the teacher. In a Piagetian classroom, an important teacher role is to provide a rich environment for the spontaneous exploration of the child. A classroom filled with interesting things to explore encourages students to become active constructors of their own knowledge (their own schemas) through experiences that encourage assimilation and accommodation

There are two key Piagetian principles for teaching and learning:

- **Learning is an active process:** Direct experience, making errors, and looking for solutions are vital for the assimilation and accommodation of information. How information is presented is important. When information is introduced as an aid to problem solving, it functions as a tool rather than an isolated arbitrary fact.
- **Learning should be whole, authentic, and "real":** Piaget helps us to understand that meaning is constructed as children interact in meaningful ways with the world around them. Thus, that means less emphasis on isolated "skill" exercises.

It is therefore recommended that when teaching any topic, the teacher has to take cognisance of the fact that learners are unique and they as a result understand differently. This then requires teachers to vary teaching and learning strategies to try and accommodate all learners.

Social constructivism

Social constructivism, strongly influenced by Vygotsky's (1978) work, suggests that knowledge is first constructed in a social context and is then appropriated by individuals (McRobbie & Tobin, 1997; Eggen & Kauchak, 2004). That is, social constructivism purports that learning is socially mediated in a social context. According to social constructivists, the process of sharing individual perspectives called *collaborative elaboration* (van Meter & Stevens, 2000) results in learners constructing understanding together that would not be possible alone.

Vygotsky's (1978) zone of proximal development (ZPD) – defined as the distance between actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers embraces this concept, as does Bruner's instructional principles as outlined by Ferrer (n.d.) who states that:

- Instruction must be concerned with the experiences and contexts that make the learner willing and able to learn (readiness).
- Instruction must be structured so that it can be easily grasped by the learner (spiral organization).

Vygotsky (1978) observed that when learners were assessed on tasks which they worked on without help, they did not perform as well as they did when they worked collaboratively with adults or other learners. This is not necessarily because an adult is teaching the learners all the time but because the engagement with an adult helps the learners to refine their thinking and as a result helps learners to perform better. A learner interacting with an adult or with other learners will thus enter another zone or level of understanding to reach attainable levels of expectations and beyond expectations.

The social constructivist scholars view learning as an active process where learners should learn to discover principles, concepts and facts for themselves, hence the importance of encouraging guesswork and intuitive thinking in learners (Rolfnus & Ackerman, 1996). In fact, for the social constructivist, reality is not something that we can discover because it does not pre-exist prior to our social invention of it. Kukla (2000) argues that reality is constructed by our own activities and that people, together as members of a society, invent the properties of the world.

Other constructivist scholars agree with this and emphasize that individuals make meanings through the interactions with each other and with their environment. Knowledge is thus a product of humans and is socially and culturally constructed (Ernest, 1991; Prawat & Floden, 1994; McRobbie & Tobin, 1997; McHonan, 1997). McMahan (1997) agrees that learning is a social process believing learning is not a process that only takes place inside our minds, nor is it a passive development of our behaviours that is shaped by external forces. Rather, meaningful learning occurs when individuals are engaged in social activities.

According to the social constructivist approach, instructors have to adapt to the role of being facilitators and not teachers (Bauersfeld, 1995). Whereas a teacher gives a didactic lecture that covers the subject matter, a facilitator helps the learner to get to his or her own understanding of the content. In the former scenario, the learner plays a passive role whereas in the latter scenario the learner plays an active role in the learning process.

The emphasis thus turns away from the instructor and the content, and towards the learner (Gamoran, Secada, & Marrett, 1998). This dramatic change of role implies that a facilitator needs to display a totally different set of skills than a teacher. According to Rhodes and Bellamy

(1999), a traditional teacher tells, a facilitator asks; a traditional teacher lectures from the front, a facilitator supports from the back; a traditional teacher gives answers according to a set curriculum, a facilitator provides guidelines and creates the environment for the learner to arrive at his or her own conclusions; a traditional teacher mostly gives a monologue, a facilitator is in continuous dialogue with the learners. A facilitator should also be able to adapt the learning experience ‘in mid-air’ by taking the initiative to steer the learning experience to where the learners want to create value. It is acknowledged, however, that for a teacher to be a good facilitator he or she needs to be knowledgeable in both the subject matter knowledge as well as the pedagogical content knowledge.

2.2.2 Pedagogical Content Knowledge

The concept of pedagogical content knowledge (PCK) refers to teachers’ interpretations and transformations of subject matter knowledge in the context of facilitating learning. Notably, PCK encompasses understanding of common learning difficulties and preconceptions of learners (Van Driel, Verloop & de Vos, 1997).

Loughran, Milroy, Berry, Gunstone and Mulhall (2001) are of the opinion that to see PCK in the classroom or in a teacher’s articulation of their practice, is to see a mixture of interacting elements which when combined help to give insights into the PCK informing the practice. They further argue that every single teaching situation is different and that means that the observable elements vary, and so the fact that PCK is portrayed as informing the practice in any given instance is quite possibly variable itself. Therefore, changes in any of the elements observed inevitably influences the nature of the PCK portrayed and it is these observable elements that are available to us in any portrayal of PCK in action.

In this study the term PCK refers not only to pedagogy, learners, subject matter and the curriculum but it also encompasses knowledge developed from prior knowledge of learners and various strategies to be used by teachers to identify learners’ difficulties in order to enhance learners’ conceptual development and understanding.

For instance, the first key component of PCK as acknowledged by Hallim and Mohm-Meerah (2002) is the knowledge of learners’ understanding, conception and misconception of specific topics, which helps teachers to interpret learners’ actions and ideas as well as to plan effective

instruction. They also confirm that experienced teachers who are very knowledgeable in their subject but fail to consider learners' way of thinking about the subject matter often faced difficulty in teaching content.

So, this indicates that without considering learners' views of the topic, teachers' expertise can be a source of difficulty in teaching and learning. These findings support the assertion generally found in the literature that a good understanding of the subject alone is insufficient for effective teaching.

Hallim and Mohm-Meerah (2002) further portray the second key component of PCK as the knowledge of presentation of specific topics which refers to the knowledge of specific strategies that are useful in helping learners to understand specific science concepts. This involves knowledge of ways of representing specific concepts to facilitate learners' learning. Representations include illustrations, examples, models and analogies.

2.3 Chemistry content knowledge in Grade 9

2.3.1 The periodic table of the elements

One of the most crucial sections to take learners through so that they can be able to master chemical reactions is the periodic table. From my experience, as I go around the schools monitoring and supporting teachers in Natural Sciences I always notice that most teachers tend to neglect the importance of teaching the periodic table as an introduction of chemical reactions. This really hampers the mastering of chemistry by learners.

In 1869, two chemists, Dimitri Mendeleev from Russia and Julius Lothar Meyer from Germany, independently proposed an arrangement of elements in what is now called the periodic table. Both scientists arranged the elements in order of increasing mass and according to similarity in properties, leaving gaps where no known element fitted in.

Ninety three of the elements with atomic numbers 1 through 94 occur naturally on earth. An atom's atomic number is defined by the number of protons in its nucleus. All atoms of a given

element have the same number of protons and are also identical in all respects but atoms of different elements differ in all respects.

The periodic table lists the elements in horizontal rows called periods in order of increasing atomic number. The vertical columns are called groups and it is where elements that have similar properties lie. The table also lists a mass for each element and a number of electrons in its electron shells, layers at various distances from the nucleus where the positively charged nucleus holds the negatively charged electrons according to how much energy they have.

Furthermore, the periodic table consists of groups and periods. I will now look at the groups of the periodic table. These are from 1 to 18. Hydrogen has properties unlike any other element in the periodic table. Though it is found in the metallic region of the periodic table, it is a non-metallic gas. It is diatomic found as H_2 . Hydrogen reacts slowly with other elements at room temperature but may react fast when heated or catalysed. Hydrogen is used in the manufacture of ammonia, sulphuric acid and methanol.

Group 1 (except for hydrogen) is known as Alkali Metals. Alkali metals are highly reactive, combining readily with air and water. Though they are metallic, their densities are low (only rubidium and cesium are denser than water) and are soft enough to be cut with a knife. The high reactivity of alkali metals comes from the fact that they have only one more electron than the very stable noble gases. As a result they react vigorously in attempts to lose the extra electron.

Group 2 are known as Alkaline Earth Metals. The alkaline earth metals have many of the same properties as the alkali metals, although they are less extreme in terms of properties. For example, most alkaline earth metals react with air and water, but much less violently than the alkali metals. Alkaline earth metals are generally harder than the alkali metals, but are still softer than many other metals. The diminished reactivity of the alkaline earth metals can also be explained by their electron configurations. Because they have to lose two electrons to become like a noble gas, they are somewhat less reactive than the alkali metals.

Group 3-12 are known as d-Transition Metals. Though properties of the d-transition elements vary greatly, many of them are hard, have high melting and boiling points, are excellent conductors of heat and electricity and have moderate to low reactivity. Transition metals are used

for a variety of purposes such as structural materials in buildings, power transmission lines, jewellery and knives.

Group 17 is known as Halogens. These are highly reactive elements that combine readily with metals to form salts. The extremely high reactivity comes from their electron configurations, because they need only one more electron to have the electron configuration of a noble gas, they react vigorously to pick up that electron whenever possible. The halogens are diatomic elements, meaning they have the general formula X_2 (for example Fluorine exists as F_2 in its pure form). Fluorine and Chlorine are gases under standard conditions, while Bromine is a liquid and Iodine is a solid. Halogens are widely used in water treatment, in the manufacturing of other chemicals and in plastics such as Teflon.

Group 18 is known as Noble Gases. Noble gases are almost entirely non-reactive. This lack of reactivity stems from the fact that, completely filled s-and p-orbitals make them very stable. As a result, very few noble gas compounds can be made.

f-Transition Metals sometimes known as ‘inner transition metals’, are the elements that are found in the two rows at the bottom of the periodic table, and are not said to be in any of the 18 groups. The top row, also known as lanthanides, consists of shiny, reactive metals. Because many lanthanides emit coloured light when hit by a beam of electrons, they are used as phosphors in television sets and fluorescent light bulbs. The bottom row also known as actinides, are primarily radioactive elements that have a wide variety of uses such as nuclear fuel sources, smoke detectors and atomic bombs.

2.3.2 The chemical classification of matter

Many chemistry textbooks provide a diagram in their introductory sections showing how matter can be classified into mixtures and pure substances, and then to heterogeneous and homogeneous mixtures, elements and compounds. The following concept map will assist teachers to know the scope of the content to be taught in Grade 9 on the chemical classification of matter as it is stipulated in the work schedule. This serves as a guideline to what teachers need to cover in this grade.

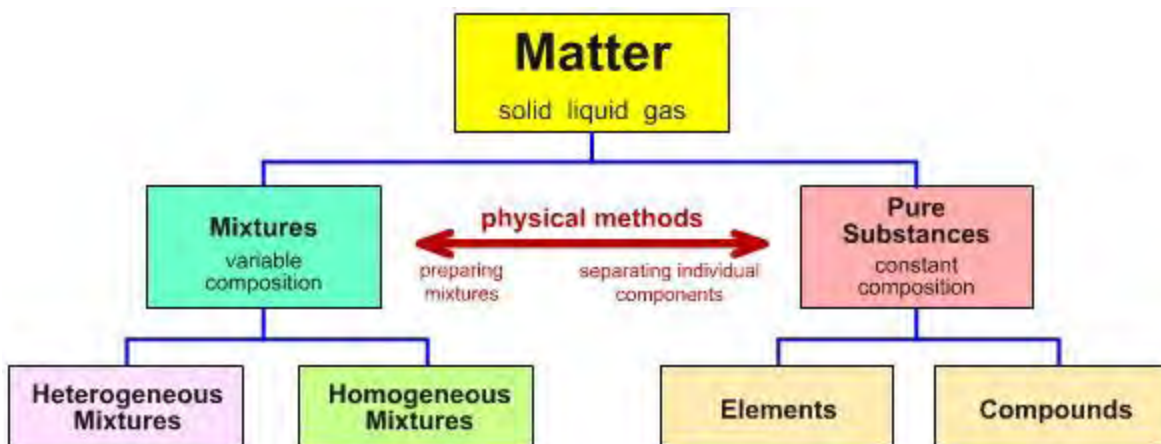


Figure 1 - Chemical classification of matter (Leach, 1999)

Matter, the stuff from which our physical world is formed, presents us with various types of materials. On a first analysis, the possible phases are:

- gaseous, such as air
- liquid, such as water
- solid, such as rock

However, for classification purposes it is useful to divide materials into:

Mixtures: variable composition

Pure substances: stoichiometric composition

Physical techniques such as: distillation, filtration, crush-and-sort, selective dissolution, chromatography, and so forth, can be used to separate the individual components of a mixture into chemically pure substances, and physical methods such as turbulent mixing can be used to blend pure substances together into mixtures.

According to the work schedule for Grade 9, the above information is taught as an introduction of chemical reactions. What I feel should be added to the schedule, however, is to give learners more examples of the pure and impure substances. The other important factor is dealing with how the mixtures and compounds are formed and ways of separating them. Learners should be encouraged to do the separation practically.

It is also suggested that teachers should differentiate between physical and chemical separation of these substances. Finally, it is suggested that learners be given an opportunity to note differences between mixtures and compounds because they could appear to be the same.

2.3.3 Chemical reactions

The Natural Sciences as a learning area is comprised of four strands, namely, Life and Living, Energy and Change, The Planet Earth and Beyond and lastly, Matter and Materials (Policy Document Grade R-9, 2002). This study is concerned with the theme Matter and Materials because it is where most of the chemistry section is contained, especially in Grade 9. The Matter and Materials strand deals with the properties and uses of materials. It focuses on understanding their structure, changes and reactions in order to promote the desired changes.

In the Eastern Cape Provincial Content Mapping and Work Schedule for Intermediate and Senior Phase Natural Sciences document (2009); chemical reactions are extensively dealt with in Grade 9. In this grade, learners have to know that matter is composed of atoms and has chemical and physical properties. They also have to examine information on the Periodic Table to recognize that elements are grouped into families (see Section 2.3.1). In addition, learners have to understand the basic concepts of mass.

Furthermore, practical activities are encouraged to allow learners to demonstrate evidence of understanding in chemical reactions. They have to use chemical formulae and balanced equations to show chemical reactions and the formation of new substances (compounds).

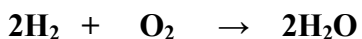
Chemical reactions occur when molecules in close proximity gain energy (activation energy) which increases their kinetic energy. This energy enables the atoms or molecules to move about, collide, and in the process form new products. During chemical reactions, bonds within reacting molecules are broken and new bonds are formed. Thus reactants are converted into products. Neither matter nor energy is created or destroyed during chemical reactions (Westbroek, 2000).

There are so many types of chemical reactions and it is helpful to classify them into **four** general types which include the following:

- ❖ Synthesis reaction where two or more simple substances combine to form a more complex substance. Two or more reactants yielding one product is another way to

identify a synthesis reaction. For example, simple hydrogen gas combined with simple oxygen gas can produce a more complex substance-**water**.

The chemical equation for this synthesis reaction is



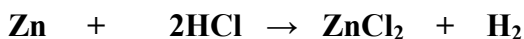
Reactant + reactant \rightarrow product

- ❖ Decomposition reaction where a more complex substance breaks down into its more simple parts. One reactant yields two or more products. Basically, synthesis and decomposition reactions are opposites. For example, water can be broken down into hydrogen gas and oxygen gas. The chemical equation for this decomposition reaction is as follows:



Reactant \rightarrow product + product

- ❖ Single replacement reaction. In this reaction a single un-combined element replaces another in a compound. Two reactants yield two products. For example, when zinc combines with hydrochloric acid, the zinc replaces hydrogen. The chemical equation for this reaction is:



Reactant + reactant \rightarrow product + product

- ❖ Double replacement reaction. In a double replacement reaction parts of two compounds switch places to form two new compounds. Two reactants yield two products. For example, when silver nitrate combines with sodium chloride, two new compounds, silver chloride and sodium nitrate, are formed because sodium and silver switched places. The chemical equation for this double replacement reaction is:



Reactant + reactant \rightarrow product + product

It has been indicated earlier that chemical reactions involve a change in energy and that during a reaction this energy is neither created nor destroyed but it is simply absorbed from its surroundings or released into its surroundings. This means that chemical reactions can be described as **endothermic** and **exothermic** reactions.

An endothermic reaction is when energy is absorbed; meaning energy is required for the reaction to occur. The energy absorbed is often heat energy or electrical energy. Adding electrical energy to metal oxides can separate them into pure metal and oxygen. Adding electrical energy to a sodium chloride solution can cause the table salt to break into its original sodium and chlorine parts.

On the other hand, chemical reactions in which energy is released to the surroundings are exothermic. The energy that is released was originally stored in the chemical bonds of the reactants. Often the heat given off causes the product(s) to feel hot. Any reaction that involves combustion (burning) is an exothermic chemical reaction (Atkins & de Paula, 2006).

2.4 What basic concepts do teachers need to consider when teaching chemical reactions?

It is known that the subject of ‘chemical reactions’ is one of the difficult sections in science because of its abstract nature. As a result, many of the learners have difficulty in understanding fundamental concepts associated with chemical reactions. Research on learners’ understanding of chemistry concepts has revealed that learners have many misconceptions. There is a variety of sources of misconceptions which are encountered in daily life, traditional instructional language, teachers, mismatches between teachers and learner knowledge of science, chemical terms that have changed their meanings and textbooks (Dermircioglu, Ayas & Dermircioglu, 2005). It is thus suggested that when teachers are dealing with chemical reactions, they have to consider first and foremost the basic concepts that learners need to understand before learning chemical reactions; for example, acids with metals and metal oxides and carbonates.

The following concepts can form the foundation of chemical reactions:

Reactivity of substances

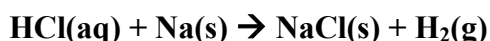
This can be dealt with at length when the teacher is teaching the Periodic Table (Section 2.3.1). Learners have to understand what reactivity means. For example, group 1 elements have a valence of one electron whereas group 7 elements have a valence of seven electrons. However, elements in both groups have a valency of one electron making them extremely reactive. Contrary to the two groups, group 8 is nonreactive because its energy level is stable.

Valence electrons are the electrons in the outermost shell whereas valency electrons are electrons taking part in a chemical reaction, for example, in the case of Hydrogen and Chlorine: Hydrogen has only one *valence electron* and can form only one bond with an atom that has an incomplete outer shell. Chlorine has seven *valence electrons* and can form only one bond with an atom that donates a *valence electron* to complete chlorine's outer shell.

Reactants and products

Reactants are the substances that are involved in the reaction. For example, a reaction of Hydrochloric Acid and Sodium can be represented as follows:

Hydrochloric Acid + Sodium → Sodium Chloride + Hydrogen gas



The substance (or substances) initially involved in a chemical reaction are called reactants or reagents. Chemical reactions are usually characterized by a chemical change, and they yield one or more products, which usually have properties different from the reactants. Reactions often consist of a sequence of individual sub-steps. The so-called elementary reactions and the information on the precise course of action, is part of the reaction mechanism. Chemical reactions are described with chemical equations, which graphically present the starting materials, end products, and sometimes intermediate products and reaction conditions.

In the case of the above chemical reaction, the reactants are Hydrochloric Acid (HCl) and Sodium (Na) while the products are Sodium Chloride (NaCl) and Hydrogen (H₂) gas. Learners need to know this information because they will frequently use it during chemistry lessons.

Particle model of matter

It is essential that learners understand all that is entailed in the particle model of matter because they will come across the information from time to time in chemistry. This is where they learn that matter is made up of tiniest particles known as atoms. An atom consists of electrons which are negatively charged and move in orbits around the nucleus: the protons are positively charged and are held by the nucleus, while the neutrons are neutral.

The atom is always neutral until it is charged. When an atom is charged it either loses or gains electrons. A charged atom is called an ion. If an atom loses an electron it will have an excess of protons and will become positively charged and is known as a cation. If an atom gains or accepts electrons it becomes negatively charged and is called an anion.

Chemical Bonding

Learners should be able to differentiate between different types of bonding and also know how each occurs. At Grade 9 level, learners are supposed to know, for example, about ionic and covalent bonding. In ionic bonding, electrons are completely transferred from one atom to another. In the process of either losing or gaining negatively charged electrons, the reacting atoms form ions. The oppositely charged ions are attracted to each other by electrostatic forces, which are the basis of the ionic bond. An example of an ionic bond is that between sodium and chlorine.

The second major type of atomic bonding occurs when atoms share electrons. As opposed to ionic bonding in which a complete transfer of electrons occurs, covalent bonding occurs when two (or more) elements share electrons. Covalent bonding occurs because the atoms in the compound have a similar tendency for electrons (generally to gain electrons). This most commonly occurs when two non-metals bond together. Because both of the non-metals will want to gain electrons, the elements involved will share electrons in an effort to fill their valence shells. A good example of a covalent bond is that which occurs between two hydrogen atoms and one atom of oxygen (Carpi, 2003).

Compounds and their formulae

A compound is a substance that contains more than one kind of atom. Every compound has a definite composition that can be described by a chemical formula. For example, water is a compound that contains two kinds of atoms, hydrogen and oxygen. Other compounds include salt and sugar. These compounds and numerous others occur in nature. Many other compounds are artificially created. Compounds are formed or broken down by means of chemical reactions. All chemical reactions involve the formation and destruction of chemical bonding. Chemical equations consist of chemical formulae and symbols that show the substances involved in chemical changes.

Each compound has its own distinctive properties. Compounds may be solids, liquids or gases. They also may have a variety of colours. Compounds can be divided into two groups: organic and inorganic compounds. Organic compounds contain carbon atoms. Proteins, fats, carbohydrates, nucleic acids and many compounds in living things are organic compounds. All other compounds are called inorganic compounds.

2.5 Challenges encountered by learners during teaching and learning of chemical reactions

The main challenges confronting learners when learning chemical reactions are the following:

- ❖ Theoretical presentation of chemical reactions by teachers, that is, spoon-feeding the learners with information instead of giving them the opportunity to construct knowledge on their own.
- ❖ The most challenging factor is the abstract nature of the concept of chemical reactions.
- ❖ Lack of practical skills as learners are not given the opportunity to do practical work since there are no laboratories, science equipment and reagents.
- ❖ There is insufficient time for practical work.
- ❖ Lack of qualified educators who have adequate subject content knowledge.

According to Faiq (2008), one of the most important challenges is translating abstract concepts into understandable ideas, for example, bonding that occurs during chemical reactions cannot be seen but only the changes are noticeable. The abovementioned challenges prevent learners from developing an interest in the study of the topic.

2.6 Challenges encountered by teachers during teaching and learning of chemical reactions

Teachers, including myself, encounter many challenges when teaching chemical reactions. First, among these is the lack of subject content knowledge. Shulman (1986, 1987) notes that one of the proposed knowledge areas required of effective teachers is subject content knowledge. He states that this refers to the extent to which the teacher needs to have the requisite knowledge in as far as content of the subject or learning area is concerned.

Flemming (1998) too observes that primary school science teaching remains problematic in many countries because of science content knowledge. This lack of understanding has a negative impact on the teaching and learning of the subject. Some science teachers would rather use science periods to teach other subjects or learning areas with which they feel more comfortable. This is very common during this time of redeployment and use of the Morkel Model to determine staff establishment for schools where the number of teachers in a school is determined by the number of learners in the school. This means that a school starting from Grade R-9 and offering nine learning areas in each grade between Grades 4-9 can have only five teachers if its enrolment is low. As a result, in such a school, teachers will be responsible for four to five learning areas in each grade irrespective of their area of specialization.

Besides the lack of subject content knowledge, teachers are also faced with the lack of what Shulman (1986, 1987) refers to as pedagogical content knowledge (PCK) which is the approach or strategies that a teacher uses during teaching and learning practices to enhance learners' conceptual understanding as well as the skill of transforming the subject content in order to make it teachable (see Section 2.3.2).

Rollnick, Bennett, Rhemtula, Dharsey and Ndlovu (2008) are of the opinion that pedagogy is not content free hence it is referred to as pedagogical content knowledge. On the other hand, Alonzo (2000) sees pedagogical content knowledge as a bridge between content knowledge and pedagogy.

Another challenge is the lack of adequate resources such as science laboratories and or science equipment in some schools. Chemical reactions are easier to teach when reactions are either performed by learners or demonstrated by the teacher as the learners are afforded an opportunity

to observe the various changes that occur. Most researchers agree that when learners carry out experiments themselves, it is easier for them to understand and remember the concepts taught than when they are merely told (Millar, 2004).

Besides the lack of laboratories, another challenge is the dearth of relevant textbooks in the schools. Most learners find it extremely difficult to associate what happens during the reaction with the chemical equation representing that reaction hence most of them are unable to write and balance the chemical equations.

Finally, is the fact that most learners have a poor understanding of English which is the Language of Teaching and Learning (LoLT) in Grades 4-12. English is a foreign language to most learners and teachers. This issue of language, together with the fact that science has got its own literature which in most cases differs from the everyday language of learners, makes it difficult for the learners to comprehend simple scientific concepts. In fact, science itself is a language and it also has an interdisciplinary nature. For example, learners need a strong mathematical background before they can master learning science.

Lemke (1990) is of the opinion that learning the language of science is not just a matter of acquiring a few specialist terms and purpose-built vocabulary items. It involves introduction to, and gaining familiarity with what he calls the ‘thematic patterns’ of science - the way in which concepts and ideas are related within a much broader network of interdependent meaning. It also entails getting used to some of the other distinctive features of scientific language which implies:

- The tendency to utilise universal rather than particularistic meaning;
- The use of technical terms and symbols in preference to colloquial terms; and
- The use of familiar everyday words in a restricted and familiarised way.

2.7 What teachers should consider when dealing with topics on chemical reactions?

It is suggested that Natural Sciences teachers should take the following into consideration when teaching chemical reactions in order to enhance meaningful learning.

- Language of the learners versus language of learning and teaching;
- The abstract nature of the concept; and

- Strategies to use when teaching the concepts within chemical reactions.

Language of learning and teaching (LoLT)

In science there are many abstract concepts which create a lot of confusion resulting in misconceptions being created. These concepts need teachers and learners to be well vested in them and the only way they can achieve that is through the use of a variety of teaching and learning strategies and code-switching (Probyn, 2004/2009) where possible. Code-switching is switching between two languages while teaching in order to enhance the learners' understanding of concepts and ideas, and for communicating these ideas. However, Probyn (2009) argues that although code-switching by teachers and learners is a common strategy to achieve a range of social and pedagogical goals, teacher training has lagged behind and there is little specific training for teachers in how to teach in bilingual situations. Nonetheless, she is of the opinion that there is much that could be learned from the practices of skilled and experienced teachers.

In the case where both learners and teachers are isiXhosa speakers, this becomes a challenge in that some scientific terms have the same meaning in isiXhosa, for example, energy, force, power are all *amandla* in isiXhosa whereas in essence they mean different things in science.

Since the language of learning and teaching (LoLT) is English (foreign language), learners and even teachers experience problems in expressing their thoughts. Vygotsky (1978) notes that there is a relationship between thinking and language, so learners think in isiXhosa (home language) and they have to respond in English (LoLT). This means that learners have to translate their thoughts from isiXhosa into English. This definitely takes time because it is not easy to translate some of the terms or concepts directly from isiXhosa to a science language. For example, learners will have difficulty differentiating between melting and dissolving because in their home language these two concepts are represented by one word *ukunyibilika*.

Learners also experience problems because they encounter English only when they are at school. In fact, both English and isiXhosa is spoken during lesson presentations whereas assessment is done in English only. Outside the classroom and even during group work discussions, interactions are mainly in isiXhosa. Learners therefore are rarely exposed to English. This affects the performance of the learners in science especially since they are assessed in English.

For instance, in most cases, learners may know the answer to a question but they may not understand what is being asked. For example, when I was checking the performance of the Grade 9 learners who wrote common tests in June 2010, all the teachers stated that the learners' performance was not good at all. However, what amazed them was that during revision time, they gave the correct responses because the questions were explained to them. This approach is unfortunately not allowed during the examinations.

This is confirmed in the report by the Trends in International Mathematics and Science Study (TIMSS) which surveyed the Grade 8 proficiency in Mathematics and Science. The survey reports that the majority of South African learners cannot communicate their scientific conclusions in the languages used for the test. Howie (2001) too claims that learners who study science and mathematics in their second language tend to have difficulty articulating their answers in open-ended questions and apparently have trouble comprehending several of the questions. In short, language competence or lack thereof is a major drawback on excellent outputs in sciences. The challenge is to improve the teaching of English across the curriculum.

Sometimes you come across a teacher who in the process of trying to explain a scientific concept, will code-switch and in the process she/he will continue teaching in isiXhosa yet the learners eventually will be assessed in English. Maselwa, and Ngcoza (2003) too in their paper on the use of practical activities in teaching and learning science, state that learners claim that language is a barrier during discussion and that English makes science very difficult. Learners feel that science would be easy if it was taught in their home language.

Vygotsky (1978) is of the opinion that language accommodates a medium for learning and is a tool to construct a way of thinking. He confirms that learning takes place in a social context through language and learners need to internalise knowledge in a related context using language. So, if learners are not competent in the language of learning and teaching (LoLT), they might come up with misconceptions.

Classroom studies in several countries show that using an unfamiliar language causes teachers to use teacher-centred methods of instruction, teachers talk while learners learn (Heugh, 2005). Interaction is reduced to chorus teaching, repetition, memorization and recall.

When language becomes a barrier to learning, teachers resort to code-switching so that they can make learning of certain scientific concepts meaningful. The teacher or the learners code switch between home language and the language of learning and teaching (LoLT). The home language serves a very important role in the sense that it serves as a mediator of thought. The teacher understands what is said and the learner is able to construct a correct idea or meaning of the science concept.

In a study conducted by Setati, Adler, Rollnick and Rutherford (1996) it was found that the use of learners' home language was a powerful means for students to explore their ideas. They further argued that without the use of code switching, some students' alternative conceptions would remain unexposed. As a science teacher, my observation was that learners' written work may conceal misconceptions which are more likely to be revealed in peer discussion in the students' home language. Also it was quite significant that when probed in their mother tongue, even shy learners began to talk and contribute to the discussion. It is therefore imperative that teachers allow learners to discuss their findings during cooperative learning in their home language first and thereafter translated into English.

Strategies to use when teaching the concepts within chemical reactions

Practical Activities

National Curriculum Statement (NCS) and the use of practical activities in teaching and learning science

The National Curriculum Statement (NCS) underpinned by the Outcomes Based Education (OBE) approach encourages the use of practical work in science classrooms. Taking into consideration the three Natural Sciences learning outcomes (LOs) and their assessment standards (ASs), they clearly depict the importance of using practical work when teaching.

In LO1 learners are expected to do scientific investigations where they have to plan for investigation, conduct investigations, collect and analyse data. In LO2 they have to construct science knowledge. Here, they recall meaningful information, categorize data, interpret information and apply knowledge they have gained from investigation. While in LO3 they are supposed to use the knowledge they have constructed to detect the effects of science and

technology in the environment so that they can make their own discoveries - for example, ways to eliminate the disturbance of the ecosystem through technology or/and science (Policy Document Grade R-9, 2002).

A variety of the forms of assessment used such as investigations, research, practical activities, case studies, translation tasks, concept and mind mapping and presentations in science also designate the importance of using practical activities in learning and teaching. Group work (cooperative learning) is of prime importance during practical activities. It is where learners share ideas, respect each other and each one of them is responsible for his/her learning as each has a role to perform. Group work also encourages a sense of ownership to learning and learners assist each other because in case one has not understood in the class, s/he understands better when it is discussed in his/her group.

The NCS also encourages the incorporation of prior knowledge in science teaching and learning and so it is proposed that teachers should consider the elicitation of prior knowledge and learning preferably when introducing a new lesson to encourage continuity and progression of concepts. Fisher (2004) highlights that researchers have discovered that in college science classes, the prior knowledge of learners determines to a large extent what each individual can learn from a particular situation. He further states that it is not productive to simply try and pour facts into learners' brains, but that each learner must assimilate and make sense of new ideas by connecting them to what they already know (Stears, Malcolm & Kowlas, 2003; Oloruntegbe & Ikpe, 2011).

Letting students voice their views is also one of the key features of the NCS. This is known as discourse. The discourse can be between the educator and the learners or among the learners themselves. Talk is an important component of practical work. Learners need to describe their observations and reasoning and to interpret how other students are thinking. Good questions posed by the teacher in the form of scaffolding can enhance a fruitful discourse by contributing to the development of concepts and vocabulary and by helping students connect ideas among the sciences. It is recommended that teachers should always give learners an opportunity to ask questions as well. Insightful questions promote thinking and draw students into sharing, observations, communicating ideas and uncovering relationships (Kohara, Kutsunai & Peiterson, 2010, pers. com.).

Practical work and constructivism

Practical work in the teaching and learning of science has been one of the most recommended and well recognized teaching and learning approaches worldwide. Practical work is very rich in the development and acquisition of skills, because within practical work activities a lot of scientific skills are embedded, namely, observation and comparison, measuring, recording information, sorting and classifying, interpreting information and so on (Revised National Curriculum Statements, 2005: 13-14). All the above-mentioned process skills refer to the learners' cognitive activity of creating meaning and structure from new information and experiences and can, in reality, be explicit when learners are engaged in practical work.

When learners are engaged in practical work they become 'hands-on', 'minds-on' and 'words-on' (Maselwa & Ngcoza, 2003) with the content. This encourages them to retain what they have learnt for a longer period rather than memorising. In fact, practical work contextualizes the content and encourages learners to construct their own learning because during practical activities, learners will be observing and from their observations discussions will emerge which will encourage them to do more research until they reach consensus. It is of vital importance though, for the teacher to facilitate learning at all times so as to avoid learners going astray or deviating from what they are supposed to do.

Strengths of practical work in teaching and learning of science

Hodson (1990) is of the opinion that hands-on practical work like experiments can be regarded as an enjoyable and effective form of learning. Learners' retention span is increased particularly when they experience science themselves (Maselwa & Ngcoza, 2003). Through practical activities learners will acquire scientific knowledge, as they will be engaged in discussions and the sharing of ideas and will also know how science and technology affect the environment and how they can use non-renewable resources sparingly (LO3: Natural Sciences R-9).

As far as enjoyment is concerned, it is clear that when they are engaged in practical work, learners will own learning as they are directly involved through active participation. This will make them regard learning as a hobby instead of a stressful experience especially science which is always regarded as a boring subject which only caters for gifted learners. Learners become focused on what they do and therefore their concentration span is extended.

We cannot run away from the fact that, during practical work, learners are in most cases working in pairs and in groups. So, while they are busy with practical activities, other than conceptual development, learners develop a lot of social skills such as respect, responsibility, cooperative learning and team work. During practical work, learners will be engaged in discussions and they will be expected to respect all the ideas and views that emerge during discussions. They will be expected to argue in some instances, but must be encouraged to reach a consensus. In this manner they will also be sharing ideas as well as assisting one other especially those learners who take time to understand.

According to Hodson and Hodson (1998), when working well, learning groups can help students identify and correct conceptual misconceptions, inappropriate inquiry strategies and poor learning methods; can stimulate the generation of new insights and new problem solving skills; and can contribute substantially to self-esteem and personal motivation by providing an emotionally secure social environment in which students can see others having difficulties and overcoming them.

Practical work allows development from concrete situations to abstract ideas and can be the vehicle for the arousal of curiosity and appreciation of aesthetic aspects of the subject (Hodson, 1990: 33). In practical work, learners are exposed to a number of skills such as observation, measuring, recording and so on which will be needed in real life situations. Small group discussions which emanate from investigations acknowledge the existence of students' ideas and allow students to explore the limitations of the usefulness of their ideas in working towards a more scientifically, acceptable model (Ramsden, 1994: 9).

Ramsden (1994) further confirms that when engaged in practical work, learners become much more involved in the lesson; they become much more enthusiastic about the subject and they can freely opt for science-related careers. Science becomes interesting and enjoyable and learners are motivated. Science is then seen as not only for brainy people, but something for everyone (Ramsden, 1994: 13). Retention of the content is increased through practical work. According to Millar (2004: 10), students do remember observable aspects of practical tasks, often many months or even years later, particularly when the event is striking. However, there is a danger of equating activity to learning during practical work activities. That is, the fact that learners are actively involved during practical activities does not guarantee that learning is taking place.

Nonetheless, as an inquiry, practical activities encourage learners to contribute to the progression of a lesson by suggesting ideas, asking questions and sharing existing knowledge. Learners talk and share their ideas with other learners and with the teacher. Learners keep record of their ideas, questions and existing knowledge by writing or drawing or representing it graphically. In this way, learners assume ownership and responsibility for their own learning. Writing and drawing which often occurs when learners record their findings, help learners to make links between their ideas (Rowell, 2005: 3).

Weaknesses of practical work in teaching and learning science

Practical work is time consuming. To complete a task in practical work one needs to have ample time without which one's activities will not reach the conclusion which is the core of practical activity because it is there where discussions and explanations emerge. This will also result in covering a limited portion of content, making it difficult for the teacher to cover all the content in the work schedule.

In some cases, teachers tend to leave learners on their own when engaged in practical activities arguing that learners should work independently so that they can construct knowledge on their own. Vygotsky (1978) cited by Hodson and Hodson (1998) argues that while most everyday learning occurs spontaneously in the context of everyday experience, the learning of science has to be organized, via contrived situations, but left to their own devices, learners will not construct the necessary understanding for themselves (Hodson & Hodson, 1998: 17).

Practical work activities can be costly especially in those schools that lack resources. Teachers are then challenged to improvise by buying some of the substances from the supermarket. Stingy teachers will regard this as a burden, whereas only dedicated and committed ones will not complain.

It becomes a problem conducting a practical activity when the teacher is not appropriately acquainted with the desired content knowledge and pedagogical content knowledge (PCK). She or he might not be in a position to plan for an activity. This is very common in South Africa since the implementation of rationalization and redeployment where teachers are forced to teach learning areas or subjects in which they never specialized because there is no one else to teach them.

Planning a good practical activity lesson

Thorough planning is very crucial when one is planning any lesson especially one which is going to involve practical activities. The following are a few proposed guidelines when planning:

Teachers should be careful not to be ambiguous or use language with big words when writing instructions especially to multiracial learners or learners whose home language is not the language of learning and teaching (LoLT), English, in the case of South Africa from Grades 4-12. Learners will not understand what is expected of them though they may know the answer. This will make them depend solely on the teacher for assistance.

It is also advisable to elicit, link and incorporate learners' prior everyday knowledge, and their indigenous knowledge, if possible, during teaching and learning, at the beginning of a lesson. Recognition of learners' prior everyday knowledge is one of the most critical aspects encouraged by NCS-OBE approach. It is best to always start from known to the unknown. Maselwa and Ngcoza (2003) agree that the inclusion of prior everyday knowledge in science lessons is important in making links and connections between the learners' knowledge and that of the teacher.

Scaffolding as stepping stones by the teacher for the learners to have conceptual understanding is recommended. By so doing the teacher will be levelling the ground and building the context for the learners. This may be in the form of questions which will direct them towards a desired outcome. The teacher should be careful though because too much guidance can interfere with learners' thought processes, and frustrate problem-solving and lead to premature closure; while too little guidance can leave learners unable to make satisfactory progress and can lead to feelings of frustration and even alienation (Hodson & Hodson, 1998: 20).

Worksheets are very important tools which can serve as a guide to learners. Well-designed worksheets guide the learners exactly to what they are supposed to do and what is expected of them.

Feedback in the form of reflections and corrections should take place after each and every activity so that the learners can communicate their findings, analyse and evaluate data. This can

be done through written or oral presentations, discussions or debate or even translating the information graphically or diagrammatically.

Activation of prior knowledge

Researchers have discovered that in science classes, prior knowledge of learners determines to a large extent what each individual can learn from a particular situation (Roschelle, 1995). It is not productive simply to try and pour facts into their brains. Each student must assimilate and make sense of new ideas by connecting to what they already know. Eliciting and finding ways to challenge prior learning can be critical for successful learning. It has also been realised that knowledge construction is hard work, especially when knowledge is counter-intuitive and defies everyday experience (Fisher, 2004).

Giving learners an opportunity to predict during practical activity lessons should be encouraged because by predicting what will happen requires learners to construct a mental model for a phenomenon that draws upon each learner's prior knowledge. Maselwa and Ngcoza (2003) and Fisher (2004) suggest that encouraging learners to discuss their predictions in small groups and then ask each learner to write down his/her individual prediction can yield better results of knowledge.

It must be noted that before teaching chemical reactions there are concepts that learners should be taken through which act as the introduction or the basis of chemical reactions (see Section 2.8). These concepts are then regarded as prior knowledge of learners.

Science discourse

Classroom discourse is one of the most successful strategies that could be used to curb the problem of misconceptions in science teaching and learning. It is suggested that teachers should create an environment that is conducive to science discourse. This can be achieved by always probing learners' thoughts through the use of structured questions and contextual clues such as resources. In order to engage learners to their maximum and deepen their understanding of language and content, comprehensible input must be transformed and students must be given ample opportunity to use their languages for authentic communication, collective knowledge generation and affirmation of personal identities.

Accompanying talk with as many contextual clues as possible is advisable because illustrations make content simpler and enable learners to generalize. The content needs to be contextualized within the framework that encompasses both teacher talk and learner talk for the teacher to provide context support (Lemke, 1990).

Planning instructional activities that will make content accessible is also crucial. Tasks should be cognitively demanding and context embedded (Cummins, 2000) at the same time allowing learners to acquire abstract concepts. Teachers must design instructional approaches that make the abstract concrete. So, this means that teachers need to plan for instructional experiences that provide for learner interaction and communication.

Collaborative learning

In any classroom, particularly science classrooms, collaborative learning enhances the learners' capacity to overcome the most challenging areas they encounter in science lessons due to a LoLT which is foreign to them. When learners work together in groups or in pairs, they share ideas, become involved in their learning and in the process those learners who missed out on some salient points from the teacher will be able to catch up as they will be using their own language when discussing the concepts. It is evident that learners become free when they learn from their peers and this makes it easy for them to ask for clarity as they feel more at ease with their counterparts than they do with the teacher.

Cooke (1998) notes that collaborative learning activities extend the opportunities for learners to use oracy as a means of learning as it is apparent that most of these activities involve reading and naturally writing. She further states that a feature of most of collaborative activities is the way in which the learners' activity leads them to reconstruct a key visual.

Collaborative learning activities also aim at improving opportunities for learners to engage with knowledge, concepts and skills in a way which allows them to bring their own experiences, ideas and activities to the learning situation and make connections between these and the new learning in which they engage. In order to achieve this, however, the activities should present the learning as a problem to be solved in a context which supports learners' understanding and encourages reflective and problem-solving talk (Cooke, 1998).

2.8 Concluding remarks

The above section has reviewed the literature relevant to this study. Literature reviewed included the theoretical framework underpinning the study which is social and cognitive constructivism as well as pedagogical content knowledge (PCK). The three factors mentioned above are quite in line with the study since they strive to equip the teachers with knowledge and skills so that they can be able to teach chemical reactions meaningfully.

This chapter also focused on the following topics:

- Grade 9 chemistry content knowledge;
- The concepts that need to be considered when teaching chemical reactions;
- Challenges encountered by learners and teachers when learning/teaching chemical reactions; and
- What teachers need to consider when teaching chemical reactions.

The next chapter deals with the methodology used to gather data.

Chapter Three

Methodology

3.1 Introduction

This chapter deals with the methodology used to gather data for this study. Important aspects of the methodology research process and the research techniques used are examined and discussed in greater detail. These include the rationale for the study, research sites and participants, the research design, data analysis, validation and limitations of the study. A number of data gathering methods were used in the study and each one of them is explained in relation to its structure and purpose respectively.

3.2. Rationale for the study

The rationale for this study was to investigate how Natural Sciences teachers mediate learning in order to enhance learners' conceptual understanding of chemical reactions, specifically, reactions of metals, metal oxides and carbonates with acids in Grade 9. This was a specific reference to two teachers in the Lady Frere District.

3.3 Research sites and participants

Mfundisweni JSS (pseudonym): First School (S1)

The school is a Junior Secondary School which caters for Grade R to 9 learners. It is situated in the outskirts of the Eastern Cape Province in the village known as Greyspan which is demarcated under the Lady Frere District. The school is under-resourced with regards to science equipment, so much so that the teacher had to improvise in some instances so that her lesson could be successful.

The classrooms are adequate, well ventilated, neat and spacious. There is enough furniture for the learners as they were sitting two at a desk. The school has electricity, tapped and tank water. Ablutions for both teachers and learners are available. In fact, the school is one of the well-managed schools in the District because whenever you arrive there, you notice that teachers use tuition time effectively as learners are always in their classrooms except for break time.

All the learners are from the area in which the school is situated and the particular teacher stays in this village as well. Learners in the Grade 9 class are all neat and actively involved in their learning. During the lessons, they were inquisitive and always liked to explore. This was evident when they were conducting practical work activities where they would go further and investigate even what was not required of them by the worksheet.

The Natural Sciences (NS) teacher who was observed at this school started teaching in 2002 and is offering Natural Sciences and isiXhosa Home Language from Grade 7 to 9 since 2002 to date. She has a Secondary Education Diploma (STD) and an Advanced Certificate in Education (ACE).

The Grade 9 class comprised of 19 learners in which there were more boys than girls. From the teacher's file and learners' exercise books I discovered that work coverage in the NS was sufficient which meant that teaching and learning was taking place well in this school.

Esidubini JSS (pseudonym): Second School (S2)

The second school is also a Junior Secondary School which caters for Grade R to 9 learners. It is situated in the outskirts of the Eastern Cape Province in the village known as Mtsheko which is also demarcated under Lady Frere District. The school is well resourced with regards to science equipment although some of the chemicals are running out. In S2 unlike in S1, learners are from the surrounding areas as they are attracted by the outstanding performance of this school. All the teachers stay in Queenstown and they commute daily. Be that as it may, they are able to conduct extra classes in the mornings and afternoons as they use their own cars to come to school.

The classrooms are sufficient, well ventilated, neat and spacious. There is enough furniture for the learners as each learner has a table. The school has electricity, tap and tank water. Ablutions for both teachers and learners are available. The school is also among those well managed schools in the District. Learners in Grade 9 are all neat and active but some dominate others.

The Natural Sciences teacher that was observed at this school started teaching in 1991 and has been offering Natural Sciences and Mathematics from Grade 7 to 9 since then. She is the Cluster leader as well as District Learning Area Committee member. She has a Secondary Education Diploma (STD) and an Advanced Certificate in Education (ACE), B. Tech in Management and

B. Ed (Hons) in Curriculum Studies. She is the Head of Department (HOD) at this school. Her Grade 9 class has 31 learners. Teaching and learning in S2 is taking place very well.

3.4 Research design

Barbie and Mouton (2006) avow that a research design is a plan of how the study is to be conducted. Abell (2008) too, asserts that in high quality research, the researcher establishes a strong link between theoretical frame work and research question.

3.4.1 Paradigms, methodologies and frameworks

The study is located within an interpretive paradigm. According to Cohen, Manion and Morrison (2007: 384), the interpretive paradigm strives to view situations through the eyes of participants, to catch their intentionality and their interpretation of frequently complex situations, their meaning systems and the dynamics of the interaction as it unfolds.

To accomplish the objectives of this study, I used qualitative research methods to generate rich data. Creswell (1994) defines a qualitative study as an inquiry process of understanding a social or human problem, based on building a complex, holistic picture formed with words, reporting detailed views of informants, and conducted in a social setting. During qualitative research study, the researcher interacts with those s/he studies. In my study I interacted with my participants by conducting interviews and observing them while teaching. This is one characteristic of qualitative research as seen by Guba and Lincoln (1985) where the researcher tries to minimise the distance between him/her and those being researched.

Qualitative research concerns itself partly with approaches such as phenomenology, ecological psychology, ethnography, symbolic interactionism and postmodernism (Bryman, 1988), and employs research methods such as participant observation, archival source analysis, interviews, focus group and content analysis (Denzin & Lincoln, 1994). Bell (1999) confirms that no approach depends solely on one method any more than it is labelled ‘quantitative’, ‘qualitative’, ‘case study’, ‘action research’, or whatever. Methods are selected because they will provide the data you require to produce a complete piece of research. This is also confirmed by Struwig and Stead (2000) when mentioning that the term ‘qualitative research’ does not describe a single research method, and there are many research methods associated with qualitative research.

The study is in the form of a qualitative case study research. As argued by Cohen et al. (2007: 252), case studies investigate and report the complex dynamic and unfolding interaction of events, human relationships and other factors in a unique instance. In this case, each teacher is regarded as a unit of analysis. The way in which each teacher mediates learning will differ as it will be affected by a variety of factors such as the school context, the background of learners, the experience of the teacher as well as their field of specialisation.

The study is placed within a theoretical framework of cognitive and social constructivism as well as teachers' pedagogical content knowledge (PCK) (Section 2.2.2).

In constructive learning it is believed that learners construct their own scientific knowledge rather than receiving it in finished form from a teacher or a textbook. So, rather than simply accepting new information, learners interpret what they see, hear or do in relation to what they already know (McRobbie & Tobin, 1997). Danna, Campbell and Lunetta (1997) too are of the opinion that the constructivist perspective on science learning and teaching recognizes that science knowledge is not something the teacher possesses and transfers to learners; rather, learners construct science knowledge to make sense of their interactions with their world and with other learners.

The South African curriculum, National Curriculum Statement (NCS) underpinned by the outcomes based approach (OBE) is aligned with a constructivist approach in that it aims to develop the full potential of a learner. NCS strives to enable learners to achieve their maximum ability and all its outcomes encourage a learner-centred and activity based approach and it envisages a life-long learner who is confident and independent, literate and multi-skilled (see NCS Review Document, 2002).

Inclusion of PCK in this study is quite relevant because one of its features as identified by Shulman (1986, 1987) is that the foundation of (science) PCK is thought to be the amalgam of a teacher's pedagogy and understanding of (science) content such that it influences their teaching in ways that will best engender learners' (science) learning for understanding. Therefore when presenting chemical reactions to learners, teachers need to be conversant about what to teach (**content**) as well as how to teach (**pedagogy**) so as to enhance learners' conceptual development and understanding.

3.4.2 Data gathering techniques

Erickson (1998:1159) warns us that “in designing data collection strategies one needs to anticipate the variety in kinds, sources and amounts of evidence that will be necessary in order to draw credible conclusions and present them in a report”. The data sources used for this study thus included the following:

- Document analysis;
- Semi-structured interviews;
- Observations; and
- Research journals.

Data recording methods included were written field notes, audio-taping and video-taped lessons.

It was envisaged that a variety of data gathering techniques would capitalize on the strengths of each technique and help minimize weaknesses inherent in a single technique (Woods & Trexler, 2004: 74). Similarly, Arksey and Knight (1999: 22) contend that approaching research questions from different angles and bringing together a range of views has the potential to generate new and alternative explanations. In the next section I examine in detail each of these data-generation techniques.

Document Analysis

The National Curriculum Statement Policy Document Grade R-9 Natural Sciences 2002 (Matter and Materials only), Province of the Eastern Cape Education Natural Sciences Revised Content Mapping and Work Schedule for IP and SP Document (Grade 9 work schedule) were analysed. These documents were analysed jointly as they all contain the content to be taught in Grade 9. I included the CAPS document in order to see what changes there are. I also wanted to know the similarities and differences between CAPS and NCS.

The section on chemical reactions from two textbooks was analysed to determine the following:

- Sequence of the topics; that is, how they were organized, as well as the progression in terms of the concepts dealt with;
- Evaluate their compliance to NCS;

- Language used; did it make the textbook user friendly or not?
- Did they address the elicitation of prior knowledge and learning?
- How were the activities planned?

I analysed the Natural Sciences teachers' lesson plans to find out whether they were NCS compliant or not. Basically, the following are suggested contents of a good lesson plan:

- Elicitation of learners' prior knowledge and learning;
- Learning outcomes and assessment standards to be achieved;
- Activities to take place;
- Teaching and learning strategies to be utilised by the teacher;
- Assessment strategies;
- Barriers to learning which may be systemic, social or personal; and
- Reflections of what transpired during teaching and learning practices as well as how could lowlights be addressed in future to make learning meaningful.

Finally, I analysed 2009 and 2010 December and 2011 June common papers together with learners' scripts where I wanted to determine whether

- The scope of the Grade 9 content was considered or not;
- The standard of the paper was checked, that is, was matter and materials assessed fairly or not; and
- Was there a variety of questions to cater for all the learners?

Learners' examination scripts were analysed to determine their performance in matter and materials only.

Semi-structured interviews

In this study, semi-structured interviews were employed to generate qualitative and rich data sets. According to Wellington (2000:71), interviewing allows researchers to investigate and prompt things that they cannot observe. Hitchcock and Hughes (1989: 157) too point out that, semi-structured interviews are flexible compared to structured interviews and they thus provide an opportunity to probe and expand responses to allow depth to be achieved (Patton, 1990;

Millar & Glassner, 1997). However, Patton (1990) cautions that interviews should be conversational and offered in a normal style.

Face-to-face individual semi-structured interviews were conducted with the two teachers involved in the study. I used semi-structured interviews to gain a detailed picture of their perceptions (De Vos, Strydom, Fouche & Delpont, 2002:302) of the topic on chemical reactions. Also, as noted by Gay and Airasian (2000), I used interviews to obtain data that could not have been obtained from observations, to explore and probe participants' responses to gather more in-depth data about their experiences and feelings; and to examine attitudes, interests, concerns and values more easily than using observations. The semi-structured interviews were recorded and transcribed verbatim for analysis as proposed by Kvale (1996).

Through pre-interviews I was able to find out the two teachers' profiles as well as their content knowledge in as far as chemical reactions are concerned (see Appendix 2), while the post-interviews assisted us to reflect on a number of issues that transpired during the lesson presentations and how the lessons could have been improved.

Observations

The observation method was used in the study as a method of gathering primary data from two schools. Observations have a unique strength in that they allow the investigator the opportunity to gather 'live data' *in situ* hence increasing the possibility of obtaining authentic data (Cohen, et al., 2007). During the observations I was a passive observer, watching and listening to activities and drawing conclusions without interfering with the teaching and learning process. To reinforce and validate data gathered I videotaped the lessons.

I observed each participant introducing and teaching chemical reactions. According to Kellener (1997/8), one of the biggest advantages of observation is that you can do it anywhere. Barbie and Mouton (2006) too, are of the opinion that the greatest advantage of observation is the presence of the observer and thinking researcher on the scene. These authors also emphasize the importance of note-taking during observations. At least two lessons were observed from each participant and video-taped. I have to highlight here the fact that in my proposal I intended to observe three lessons from each participant but due to time constraints I ended up observing only

two lessons each. After each lesson, to strengthen the validity of my data, I watched the video together with the teacher concerned and we both reflected on what transpired during lesson presentation.

Research journals

Reflective writing can be a useful tool during the research process. My motivation to explore the issue of journal-writing stemmed from my personal experience of keeping a research journal when I was doing the ACE (Science with Maths) course at Rhodes University. I thus did not experience any problems in encouraging my research participants about journal keeping as we all did the same course. It is recognized, however, that time constraints and limitations of language was a potential barrier. Notwithstanding, it is advisable that researchers and participants keep journals in addition to their field notes of their observations.

In the journals, we took notes of our impressions, questions, emerging themes, decision making or any other issues that arose (Yin, 2003) during this research process. Having research journals is very helpful when information that earlier was very salient and memorable becomes harder to retrieve and reconstruct with time. In addition to help remember important details later on, journal keeping becomes part of the analysis and interpretation process itself as the researcher starts to mull over data and the themes.

As Borg (2001:156) points out, forms of reflective writing such as diaries and journals are widely acknowledged as important tools in promoting both development and understanding during the research process. By documenting and reflecting on their experiences, participants may benefit from an enhanced awareness of themselves as people and as professionals. Taylor and Bogdan (1998:150) propose that researchers should stand back from their data and write analytic memos on what they think they have learnt. They add that memo-writing provides an opportunity for the researcher to think about the process and reflect on, for example, what additional data they may need to generate.

Table 1: A summary of the approach followed in making sense of the data

Method	The purpose	How was data analysed?
<p>Document analysis</p> <ul style="list-style-type: none"> • RNCS Policy document • RNCS Content document • Lesson plans <ul style="list-style-type: none"> ○ CAPS document ○ Grade 9 (2009 & 2010) June and December Examinations common papers. 	<p>How the NS content is outlined in each document.</p> <p>Differences and similarities in CAPS and NCS.</p> <p>To check the standard and the level of the papers especially in chemical reactions.</p>	<p>The interest was based on the language, the level of content and how teachers elicit prior knowledge of learners when teaching chemical reactions.</p> <p>I looked at how CAPS is different from NCS and also looked at the similarities.</p> <p>The sequencing of questions, the level of the language used and the connections with the documents.</p>
<p>Semi-structured interviews</p>	<p>Teachers' perceptions on chemical reactions.</p>	<p>How teachers go about in teaching of chemical reactions and the strategies they used. And also to compare what they say to how they teach in their classrooms.</p>
<p>Observations</p>	<p>To gather data on how teachers introduce and teach chemical- reactions in their classes.</p>	<p>Observations helped me as a researcher to look for trends between the documents, what teachers say and their lesson plans. Learners' actions during teaching and learning of chemical reactions.</p>
<p>Research journal</p>	<p>Taking notes and reflections of individuals during this research process.</p>	<p>The journals were analysed based on their value in this whole process, how they helped the participants to grow in their profession as well as how these journals helped us to reflect on this journey.</p>

3.3.4 Research process

Pilot Study

A pilot study was conducted with another Grade 9 teacher who is not involved in this main study. The teacher's practice in the form of lesson plans, textbooks used and lesson presentation was observed. Data was gathered in the form of field notes. A semi-structured interview was also conducted to probe the challenges faced by the teacher on the topic of chemical reactions. As a result of the pilot study I was able to refine my data gathering techniques in preparation for my main study.

The main study proceeded as follows:

Phase 1

In phase I analysed the following documents: NCS policy document Grade R-9 (focusing only on Matter and Materials); the policy document with the Grade 9 work schedule on content mapping and work schedule for intermediate and senior phase Grade 4-9 provincial document; the section on chemical reactions in at least two textbooks used in the two schools involved in this study to find out if there are any consistencies/inconsistencies in as far as the terms and progression within the topic; the Curriculum and Assessment Policy System (CAPS) which is going to be implemented in 2014 in Grade 9. I compared it with the current Policy Document so as to find out whether there were any changes regarding the content on chemical reactions. Lastly, I analysed the Grade 9 June and November (2009/2010) Common Paper and learner scripts together with the two teachers. With learner scripts I decided to sample only five learners.

Phase 2

In this phase I observed the two teachers and video-taped two lessons each on chemical reactions. T1 presented lessons on the reaction of acids with metals and metal oxides while T2 did reaction of acids with metals and carbonates. I requested a reliable person to video-tape for me so that I could focus on observations and take field notes. It was hoped that by video-taping the lessons the authenticity of the data generated would be strengthened. Most unfortunately however, the person I requested to video-tape for me was only available during the presentation

of the first few lessons. I then ended up video-taping the last lessons on my own. This somehow disrupted my plan because I had to divide my attention between videotaping and note-taking.

Through these observations I was hoping to see how these teachers approached the topic of chemical reactions and what strategies they used when teaching it. For example, I was observing whether background knowledge of learners was elicited and incorporated and what strategies these two teachers utilized to enhance conceptual development and understanding.

After each and every lesson we had a debriefing session to reflect on the lessons.

Phase 3

During this phase, I watched the video-taped lessons with each teacher and stimulated recall semi-structured interviews were conducted as well. Walker (1996) argues that an interview relies on the fact that people are able to give explanations of their behaviour, practice and actions to the interviewer. Semi-structured interviews, in particular, allow the interviewer to make some modifications in the sequencing of questions and even changing the wording while conducting an interview (Cohen et al., 2007). In addition to that, Patton (1990) confirms that semi-structured interviews permit the interviewer to explore, ask questions which elucidate and revive the participant. As a result, the participants might feel more comfortable in answering questions.

With regards to stimulated recall interviews, Reitano (2004), states that video-stimulated recall is the least intrusive and yet the most inclusive way of studying classroom phenomena. It allows the teacher to relive an episode of teaching by providing, in retrospect, an accurate verbalised account of his/her thought processes. Videotaping allows the teacher to examine their mental models *in situ*, study changes to their schemas during and after teaching episodes, and formulate new teaching models as a result. Furthermore, videotapes give the teacher more time to reflect on classroom events and look for answers. In short, video stimulated recall allows teachers to reflect and revisit recorded scenes at any time; the videotapes can be examined to gather further specific evidence when necessary; it allows the teachers to decide for themselves what they want to focus on; and, others - critical friends and even the researcher in my case - can watch episodes and make suggestions.

Importantly, teachers can be the ones who are in control of stopping the tape at any time when they see themselves making a decision, describe what they were doing at that time, what alternatives they had considered and what they decided. In this way video stimulated recall allows for the elicitation of ‘knowledge-in-action’ or interactive cognition. However, researchers report that teachers viewing a videotape of their lessons may find the experience highly stressful and may negate teachers’ preparedness to report on what they have recalled. Fortunately, that was not the case with my teachers. They were very enthusiastic to watch their actions on the video and interviews that were conducted seemed like reflections to them.

3.5 Data analysis

Data analysis is a continuous process of making sense of the data sets generated from different methods used. Consistent with the interpretive paradigm underpinning this study, analysis thus occurred throughout the research process. Data analysis thus began on the research field whereby I analyzed data as it emerged and located it to the areas of relevance to the topic as confirmed by Ary, Jacob, Razavieh and Sorensen (2006). Ary et al. (2006) further argue that in most qualitative studies, data gathering and data analysis take place simultaneously.

The analysis thus incorporated intensive reflection and analysis to develop shared interpretations of events (Peers, Diezmann & Watters, 2003:92). Furthermore, since data analysis is an interactive process involving interpreting and making sense of such texts (Hitchcock & Hughes, 1989; Dey, 1993; Cresswell, 2003), inductive strategies and constant comparative analysis were used to identify patterns and themes in the data (Stake, 1994; Taylor & Bogdan, 1998).

Field notes from observations and semi-structured interviews were analysed one by one, keeping in mind that qualitative data must be coded in order to provide some structure and meaning. Also, evidence of similar categories needed to be grouped and reviewed until themes emerged and initial assertions were generated to help develop insights and theoretical understanding.

3.6 Ethical considerations

Ethical considerations are important in research and should be undertaken within an ethic of respect for persons, respect for knowledge, respect for democratic values and respect for the quality of educational research (Bassey & Bera as cited in Murray, 2006: 1). This suggests that I

was obliged to get permission from the principals of the participants, the District Office as well as obtaining the participant's consent.

Erickson (1998: 1160) too, suggests that "researchers are obliged ethically to anticipate what will be done in data collection, analysis and reporting" during their research studies. He further recommends written agreements when the conditions of research are specified. This is called mutually informed consent (Cohen et al., 2007).

All ethical questions were addressed and observed before and during data generation. Participants were briefed regarding the purpose of the research and their rights as participants in the research. This was done to ensure that there was informed consent, free choice to take part and to place some form of responsibility with participants with regards to what answers they would be giving (Cohen & Manion, 1994; Bell, 1999). Participants were assured of anonymity and privacy (Cohen et al., 2007).

Berg (1998: 48) also points out that confidentiality and anonymity are critical during research: explicitly, researchers need to assure participants that anything discussed between them will be in strict confidence. In this research study, the identity of the participants was concealed through the use of pseudonyms and trust was all the more essential (see Section 3.3).

The validation process in this study itself helped address ethical issues as Merriam (2001) warns that, in qualitative studies, ethical dilemmas are likely to emerge on the generation of data and in the dissemination of findings.

3.7 Validity issues

Validity is used to determine whether the findings are accurate from the standpoint of the researcher, the participants or the readers of an account. To Lather (1986a), validity in qualitative research is associated with rigor and relevance. Cohen et al. (2007) are of the opinion that using different data generation techniques ensures trustworthiness and validity of data. In this study, data validity involved: triangulation and member checks.

Triangulation is often thought of as a way of checking out insights gleaned from different sources of data (Taylor & Bogdan, 1998: 80). Denzin and Lincoln (1994) too, argue for a triangulation of multiple methods and theories saying that they can improve the likelihood that

interpretation will be acceptable, through the support they provide to each facet of data generation.

Authenticity of data was determined through member checks as encouraged by Guba and Lincoln (1985: 314). To Lather (1986a: 67), member checks entail recycling analysis back to the participants and in the context of this study member checks were undertaken throughout the study through reflections. Taylor and Bogdan (1998: 159) also say that comments from research participants can enrich the interpretation of data.

In this study, feedback to participants and checking of information were integral to the research process, and it took various forms, namely: asking participants to read transcripts of interviews, field notes from observations and video-taped lesson discussions to indicate any misinterpretations, and where necessary to clarify aspects or make amendments.

3.8 Methodological limitations

As anticipated, limitations to the study were that the two teachers that have been purposefully selected for this study do not represent the whole population of Grade 9 teachers in the Lady Frere District and therefore the findings cannot be directly generalized to the larger population. It is recognised, however, that within the qualitative inquiry, reliability and generalizability play a minor role as proposed by Cresswell (2003: 195).

My biggest challenge at the time of the study was how to have sufficient time while confronted at the same time with the Departmental programmes that sometimes emerged out of the blue and had immediate deadlines. This meant that I observed two instead of three lessons.

3.9 Concluding remarks

In this chapter I have outlined the research methods used to establish how two Natural Sciences teachers mediated learning in order to enhance learners' conceptual development and understanding of chemical reactions in Grade 9. The methodology included administration of a number of data gathering techniques, namely, document analysis, semi-structured interviews, observations and research journals. This chapter also explores how data were validated to ensure quality and trustworthiness. Finally, ethical issues implicated and limitations are also considered in this chapter. The next chapter deals with the analysis and findings of the study.

Chapter Four

Data presentation

4.1 Introduction

This chapter presents the findings from data that has been gathered to determine how Natural Sciences teachers mediated learning to enhance conceptual development and understanding of chemical reactions in Grade 9. The data was gathered by administering analysis of documents, semi-structured interviews, observations, field notes and journals.

The chapter examines the way in which the curriculum, textbooks and lesson plans are organized in order to facilitate teaching and learning. Also, analysed were final question papers for 2009, 2010 as well as 2011 midyear examinations. These were analysed together with the five learner scripts from each school.

The data was predominantly generated through observations and was inductively analysed by transcribing video interactions with the view to establish categories emerging from the teachers' practices of mediating learning when teaching chemical reactions in relation to the difficulties learners experienced in this topic.

Semi-structured interviews and field notes were analysed with the view to establish a detailed picture of two teachers' perceptions as well as to gather more in-depth data about their experiences and feelings (see Section 3.4.1).

4.2 Findings and analysis

4.2.1 Document analysis

Following are the documents that have been analysed:

a. National Curriculum Statement Policy Document Grade R-9 Natural Sciences

In NCS Policy Document Grade 9 (NS) the content in all the four strands is divided according to phases, that is the foundation phase (FP) Grade R-3, intermediate phase grade (IP) Grade 4-6 and senior phase (SP) Grades 7-9 (see Appendix 6r). This creates a big challenge to teachers in that they have to demarcate the content according to grades whereas they do not know the exact

scope for each grade; some would go below and others above the level of the learner in that particular grade. Nonetheless, the content in matter and materials in all the phases has been distributed fairly across the phases. This forced the Provincial NS Coordinator and the District Coordinators to develop a work schedule which is demarcated according to grades (see Appendix 6a).

b. Curriculum and Assessment Policy Statement (CAPS) Document

Curriculum and Assessment Policy Statement (CAPS) will be implemented in 2014 in the senior phase. There are some changes in CAPS that will make it more preferable than NCS although they will work in conjunction with each other. One thing that should be borne in mind is that in CAPS there are no longer learning areas but subjects. The content in the Curriculum and Assessment Policy Document is already planned into study areas according to grades. What the teacher is going to teach and assess is clearly stipulated. Chemical reactions in Grade 9 are still presented in the same manner as in NCS. The Curriculum and Assessment Policy Statement is promoting the importance of textbooks and practical tests in Natural Sciences (see Appendix 6q).

c. Work schedule

As I have indicated in section 4.2.1 above, the Provincial Document is derived from the policy document where Natural Sciences content is being demarcated according to grades. It is then distributed over four terms of the year. According to the work schedule, chemical reactions of acids with metals, metal oxides and carbonates are dealt with in term four. The concept map at the beginning of the work schedule clearly indicates the content in each strand, matter and materials in our case and the concepts which learners have to understand in each grade (see Appendix 6d).

The work schedule also clearly depicts the progression of concepts from one grade to the next (see Appendix 6e, f & g). Also, suggested teaching and learning strategies are stipulated for each topic for instance in the case of chemical reactions, recognition of prior knowledge and learning (RPL), predicting, observing, recording and identifying products of reactions using models or other representations of the reactions are encouraged (see Appendix 6e, f & g). With the aid of a work schedule and provided it is used efficiently content coverage in all the grades can be feasible.

Regarding the work schedule, both teachers are following it in as far as content coverage is concerned. This was proved by the fact that when looking at their Master portfolios and learners' class work books, they had covered enough work for that period.

d. Textbook Chapter on Chemical Reactions

Learners in these two schools are using different textbooks. In S1, learners are using Spot On and the teacher uses Science Today as a reference book. In S2, learners as well as their teacher are using Science Today. In addition to this, the teacher in S1 always refers to ACE modules she acquired from Rhodes University. So, I analysed the two textbooks, namely, Spot On (see Appendix 6m) and Science Today (see Appendix 6l).

In Science Today, the chapter does not cater for the elicitation of prior knowledge and learning. Instead, it goes straight to the reactions although in the second activity it always refers to the previous activities. With regards to the activities, however, all that is expected of learners to understand is clearly stipulated and it corresponds nicely with the work schedule. The only gap I noticed regarding the activities is that learners are not required to predict or hypothesise before conducting an experiment; they are just expected to observe and record changes that will take place during the activity. The textbook is user friendly for both learners and teachers because the language used is simple and suitable for English second language speakers and there is a glossary at the back to explain some terms and concepts. The illustrations are conspicuous but not colourful.

On the other hand, Spot On simply goes straight to the activities. That is, the instructions of the experiments to be conducted by the learners, and then there is just a conclusion at the end for example: "when an acid reacts with a metal, a salt and hydrogen are formed". The illustrations are well presented although they are also not colourful. The language used is simple and a glossary is also available.

I would like to mention that the content in both textbooks is a little bit shallow and as such I always suggest that teachers refer to the old curriculum textbooks for content knowledge. These two textbooks specialise on the 'how' part of teaching NS. This is evident in the teachers' guide where teachers are shown how to teach each topic and the activities to be done so as to enhance learners' conceptual development and understanding.

e. Lesson Plans

Mrs Sibotoboto (pseudonym): Teacher 1 (T1)

The duration of the lesson plan was for a week and it was intended to be covered over three periods of sixty minutes each. There is no indication of elicitation of prior knowledge and learning. This teacher's planning is brief and the activities are not explicit. Content knowledge to be covered is not clearly stipulated as the key scientific concepts to be developed are not mentioned. Progression of concepts within the learning area is not put across. Even assessment strategies and reflections are not included (see Appendix 6h, i & j). This means that in the case where a teacher is absent from school no one else will be able to assist because such a lesson plan is not user friendly.

Mrs Bongani (pseudonym): Teacher 2 (T2)

The lesson plan was for a week which was four periods of sixty minutes each. It showed how elicitation of prior knowledge and learning would take place. It clearly indicated how the teacher aimed to conduct the lesson and what activities would take place. Content knowledge to be covered is unequivocal as the key scientific concepts to be developed are well established. Reflections and assessment strategies are included (see Appendix 6k).

f. Learners' Worksheets

Learners in School 1 (S1)

No worksheets were given to learners in school 1 (S1) but each group was required to write the observations down in examination pads. This is what one of the groups wrote:

After the solution is heated the oxygen in the CuO broke away from the copper. The hydrochloric acid molecules broke down into hydrogen and chlorine. The oxygen and hydrogen atoms joined together to form water. Copper and chlorine atoms joined to form copper chloride (see Appendix 6m).

Learners in School 2 (S2)

Each group of learners was given an activity instruction document and a worksheet to complete together. The worksheets were designed in such a way that they assessed learners fairly well and

so that the teacher could be able to detect whether the learners had understood or not. In the worksheets two groups answered all the questions correctly but the third one had a problem with some of the questions.

For instance, when they were asked to write the components of a carbonate, their answer was correct but they could not write its chemical formula at all. Also when they were asked which gas they thought was produced they simply said “it produced bubbles” and that was all they could say. So, it means that all the learners in that group did not understand symbols of elements and formulae of compounds (see Appendix 6g). It is quite evident once more that when the teacher was forming the groups she did not consider the level of competence of the learners because seemingly all the members of the group had the same level of understanding.

Killen (2000) notes that the main reasons of using group work are to allow learners to share ideas, debate issues and reach a common understanding of content that will help them to achieve particular learning outcomes. It is therefore vital for the teacher to form groups that will be effective by considering guidelines for productive participation in group work.

g. Examination Papers

In the 2009 end of the year paper, question 1 was a multiple choice question with ten questions. Out of the ten questions, four questions were on matter and materials and from the remaining four questions, two were on chemical reactions. In the main question paper, questions 3, 4 and 5 were about chemical reactions. These questions were on *balancing of chemical equations, neutralization, combustion, exothermic and endothermic reactions and electrolysis*.

In the June 2010 examination paper, question 1 was a multiple choice question with ten questions and only two out of the ten were on chemical reactions. In question two learners had to match the descriptions in column A with terms in column B, and out of ten, two questions were on chemical reactions. Then question 6 was not on chemical reactions *per se*, but on matter and materials where learners were expected to recall information on the periodic table, chemical symbols and formulae and to balance the chemical equations (see Section 2.3).

In the 2010 Final paper, question 1 was a multiple choice question with ten questions of which four were on chemical reactions. In the main examination paper, questions 6, 7 and 9 were on chemical reactions. That is, reaction of an acid and a carbonate, an acid and hydroxide.

Lastly, in the mid-year examinations 2011, chemical reaction was assessed at length. Questions were varied to accommodate the diversity of learners. I liked the style of the examiners because the question on chemical reactions was in the form of a case study where learners had to understand what was taking place in the case in order to answer the questions. All the questions on chemical reactions were then formulated from that case study.

When the two teachers were asked about the standard of the question papers they agreed that the standard was improving every year. T2 even stated that “*especially the June 2011 one was in the form of the papers we used to know in the late 80s and early 90s let alone that our learners always disappoint us*”. When I asked her to explain what she meant by that she said that they were according to the expectations, and unlike the CTAs which focused on a particular theme, these papers assessed learners holistically.

h. Learners' scripts

Table 2: Marks of Grade 9 learners in November/December 2010 Common Examinations

1. Learners answer scripts	Learners	Marks obtained S1					Marks obtained S2			
		Q1	Q3	Q4	Q5		Q1	Q3	Q4	Q5
		4	10	10	10		4	10	10	10
Final 2009	L1	0	6	4	5		0	4	2	2
	L2	0	5	7	2		1	2	1	2
	L3	0	6	6	6		2	2	4	3
	L4	1	5	4	2		1	5	2	1
	L5	0	5	4	3		1	7	5	4

Final 2010	Learners	Marks obtained S1				Marks obtained S2			
		Q1	Q6	Q7	Q9	Q1	Q6	Q7	Q9
		4	12	10	5	4	12	10	5
	L1	1	2	0	5	1	2	6	3
	L2	2	2	0	2	4	2	3	3
	L3	2	2	0	3	2	5	8	5
	L4	1	5	4	3	0	1	2	4
	L5	4	2	3	5	0	2	2	4

Chart 1: Marks of Grade 9 learners in Final 2009 exam

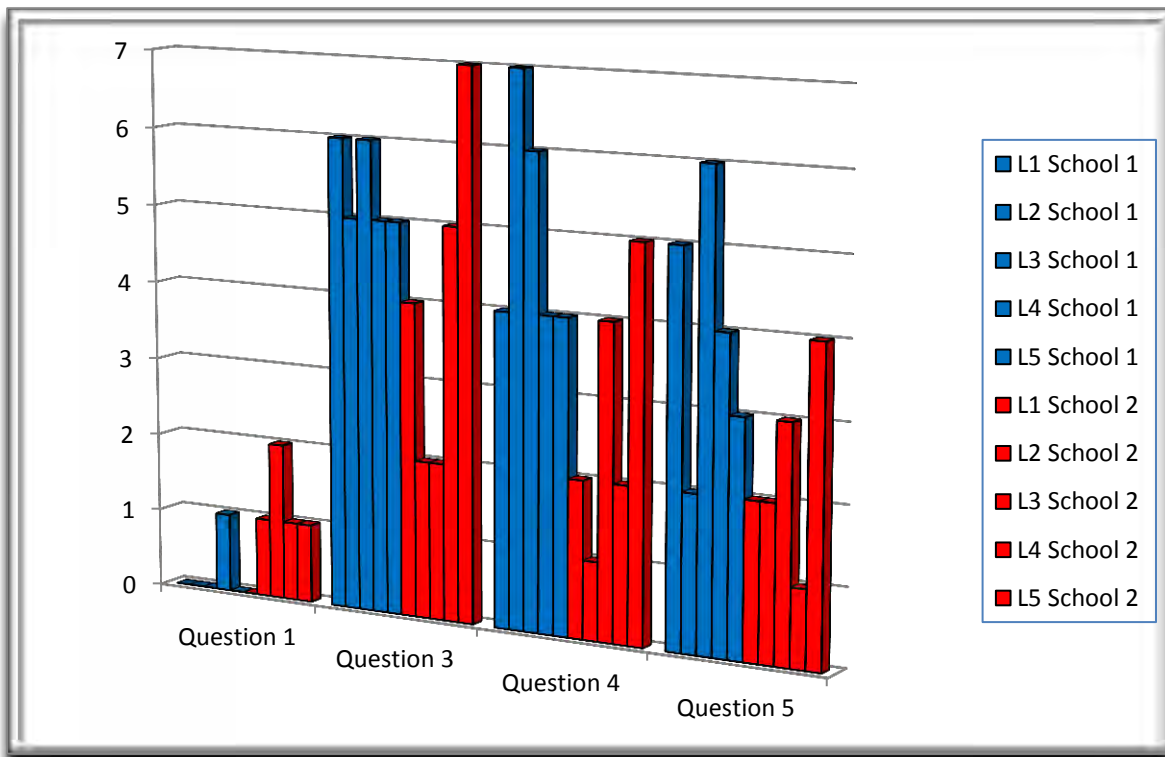


Chart 2:

Marks of Grade 9 learners in Final 2010

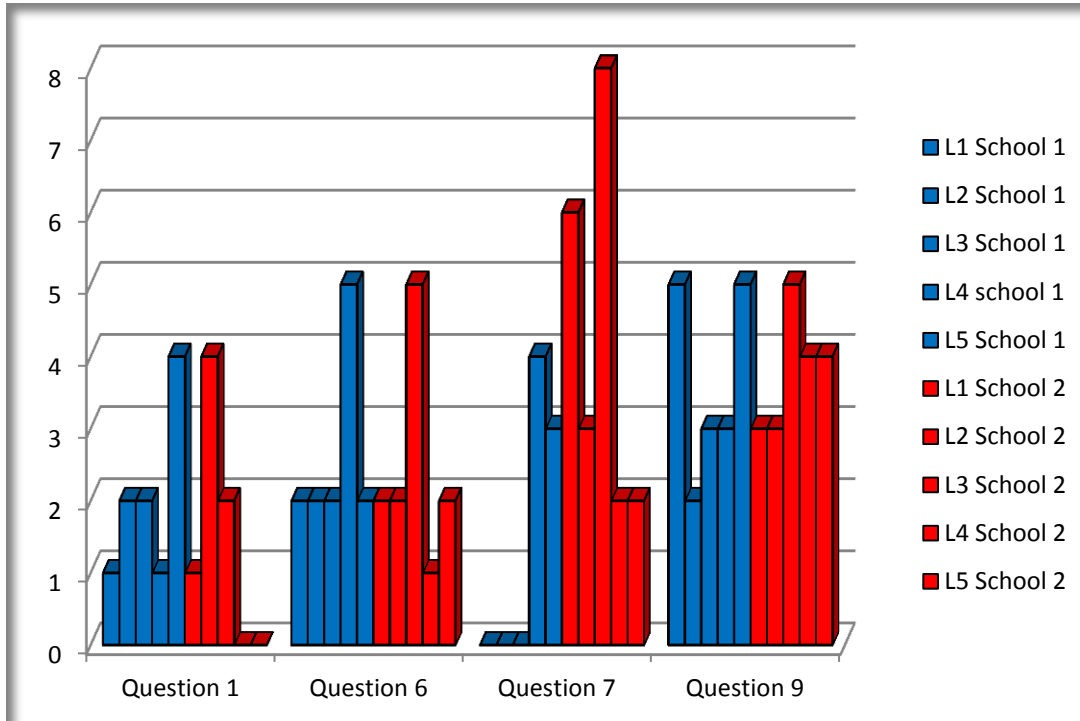
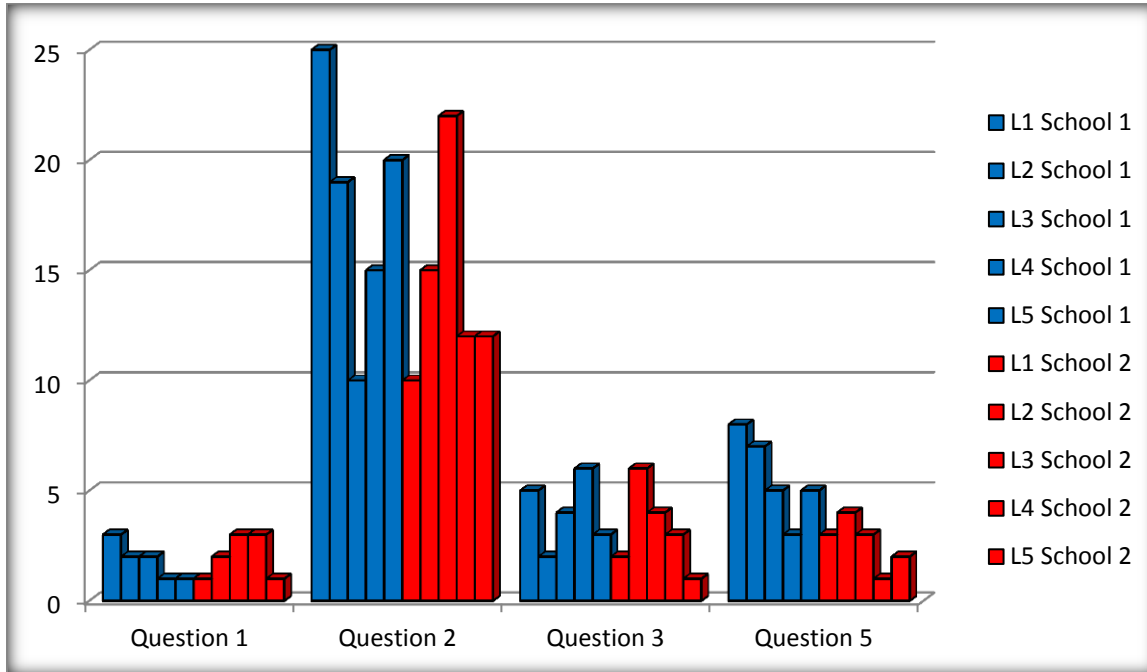


Table 3:

Marks of Grade 9 learners in June 2011 Common Examinations

June 2011	Learners	Marks obtained S1					Marks obtained S2				
		Q1	Q2	Q3	Q5		Q1	Q2	Q3	Q5	
		5	40	9	12		5	40	9	9	
	L1	3	25	5	8		1	10	2	3	
	L2	2	19	2	7		2	15	6	4	
	L3	2	10	4	5		3	22	4	3	
	L4	1	15	6	3		3	12	3	1	
	L5	1	20	3	5		1	12	1	2	

Chart 3: Marks of Grade 9 learners in June 2011 exam



In 2009, based on the information in Table 1, the most difficult question was question 1. Learners performed poorly in both schools. S1 learners were worse because out of five learners four got nothing while the fifth one got one out of four (see Table 1). Remember that question 1 is always a multiple choice question. To me, this implies that learners are challenged to answer multiple choice questions because if one can have a look at all these papers not a single learner in both schools got all the answers correct. I suggest that teachers educate learners on how to answer multiple choice questions, as it seems that they are just guessing.

Nonetheless, with reference to the overall marks obtained by the learners it is apparent that there is improvement in the setting of question papers as teacher T1 confirmed in section 4.2.1. Learners' performance had improved in June 2011 compared to 2009 and 2010. This was also confirmed by teacher T2 in section 4.2.1.

Although the question papers were straightforward and were developed according to the stipulated guidelines in the assessment guidelines, the performance of the learners at both school 1 (S1) and school 2 (S2) was not good. This confirms the comments made by the teachers that

learners do not understand the language although they know the answer because when they were revising the papers they obtained better marks (Probyn, 2009).

4.2.2 Interviews

a. Pre-interviews

These took place two weeks before the observation sessions. The purpose of the pre-interviews was to get to know the profile of the participants and to establish their knowledge about chemical reactions, what factors were influencing their teaching of chemical reactions, and what documents they used when teaching chemical reactions. The interviews went as follows:

Teacher 1

Q1. Did you specialize in Science?

T1: I could say yes because I did Science in Standard 10 and I have Advanced Certificate in Education (Maths and Science) at Rhodes University.

T2: Yes. At Matric I did Science subjects such as Biology, Mathematics and Physical Sciences. At the teacher training college I specialized in Mathematics and Physical Sciences. I also acquired Advanced Certificate in Education specializing in Mathematics and Science at Rhodes University.

Q2. How does the experience you have in teaching assist you in teaching chemical reactions?

T1: I do not have much experience because after passing my education diploma I stayed at home until nine years ago when I started teaching but I have gained experience through workshops where we are advised how to teach certain topics. We also go for moderations where teachers share ideas on the content and methodology.

T2: I have 20 years of experience in teaching, since then I have been teaching what was called General Science which is now known as Natural Sciences. So with such experience I know the topics that challenge learners within chemical reactions and I have my ways of addressing those areas immediately to avoid misconceptions.

Q3. What documents do you use when teaching NS?

T1: I use prescribed work schedule from the Province, lesson plans also from the Province, learner's book (Science Today) and Spot On as an additional resource book.

T2: *I always start from the **work schedule** because it tells me what topics to teach on a weekly basis. From there I go to the learner's book and teacher's guide (Spot On) to get the activities. To get more information I refer to the modules I got from Rhodes University they are so informative, they help me a lot. I also use other resource books like Oxford Natural Sciences and Shutter's Natural Sciences.*

Q4. How do you introduce chemical reactions? Why?

T1: *I start by teaching periodic table though it is revision, one has to teach it well especially the first twenty elements learners must know them by heart. The periodic table helps me a lot; it is where chemistry starts.*

T2: *It depends which topic am I gonna teach but I usually begin with the periodic table because to me the periodic table is the foundation of all chemistry.*

Q5. Is it easy or difficult for learners to understand chemical reactions? Why?

T1: *It is not easy because we do not have science kit we last have it from Science Education Project (SEP). When we are doing experiments sometimes we do not have enough resources and I improvise but we sometimes do not get the expected results of the experiment.*

T2: *Learners are able to understand when they do practical activities but when you assess them it becomes a problem more especially with reactants, products and balancing of chemical equations.*

Q6. What challenges are you faced with when teaching chemical reactions?

T1: *The fact that we do not have enough science equipment is a big challenge to me as I have indicated that we improvise and sometimes we do not get the expected results of the experiment.*

T2: *No laboratory so you have to be fast so as to give space for the next teacher and you cannot even set your apparatus in time. So the period of 60 minutes is too short when you are going to do practical activity like experiment. You know madam I was impressed at RU because during Science classes we always come to find out that the apparatus were already set for us, and I wish that could be the same with my learners'.*

b. Post-interviews

The purpose of the post-interviews was in a way to reflect on what transpired during the lesson presentation. They were in the form of semi-structured interviews so as to do follow-up. The following are a few questions posed at the participants and their responses:

Q1: What do you think went well with your lesson (highlights)? What is it that you think made your lesson successful?

T1: The lesson went well I cannot complain though somewhere somehow we experienced challenges. Practical activities made the lesson to be a success because learners enjoy learning when they are hands-on. They do not lose focus. Everyone was actively involved even the shy and lazy ones participated in the lessons. When they were conducting experiments, they went beyond what was required of them to show that they were enjoying. Their reports showed that they have understood at least 70% of what they learnt.

T2: I think it was successful because after conducting the experiment, learners were able to answer the worksheet correctly. They were even able to identify the reactants and the product. They know the symbols and formulae and they can now balance chemical equations with ease. I think practical activities played a vital role in the understanding of my learners.

Q2: What did not go well (Lowlights)? What made it not go well?

T1: We had a problem when learners were conducting an experiment on acids and metal oxides because of the shortage of science kits so we did not get the expected results. This may confuse learners because when they observe and see the expected results they can remember that well than when it is told to them.

T2: Having enough science equipment for all the groups was an advantage to me. So I think my lessons went well.

Q3: Did everything go according to plan? Why?

T1: Except that we did not have enough equipment, everything went according to plan because we managed to cover the work we were supposed to do within the stipulated time of 60 minutes.

T2: Everything went according to plan. I was worried about hydrochloric acid, it was not enough but I tried by all means to divide it equally amongst the groups. The main problem was with the test for hydrogen, not everybody heard the 'popping' sound and that worried me a lot.

Q4: What are your suggestions/recommendations with regards to your lesson presentations?

T1: I suggest that the school procures for science equipment and to convert one of the classrooms into a science room something like a lab so that we do our practical activities without disturbances. I recommend that when doing any practical activity learners should always be encouraged to predict the outcomes, this assists them a lot; they become excited when their prediction is correct.

T2: When groups are reporting, the teacher should take notes of the grey areas so as to probe whole class discussions by so doing even those who had misconceptions can be assisted and please allow the learners to code switch where necessary, they must not be denied from using their home language but the teacher should guard against those terms that are not directly translated in their language.

4.2.3 Observations

Both teachers were observed presenting two lessons each.

Teacher 1 (T1):

Lesson 1 (L1)

Learners were arranged in three groups: two groups with six members and the third with seven members. Lesson one was on the reaction of acids with a metal. In this particular class the practical activity that the learners conducted was on the reaction of hydrochloric acid and magnesium. In lesson 1 (L1), teacher 1 (T1) elicited prior knowledge on the properties of acids and the symbols of some elements such as magnesium, iron, and carbon. Recognition of prior learning (RPL) was lengthy and it could have been a lesson on its own. Learners demonstrated their understanding on the properties of acids but they were not comfortable with the symbols and names of the elements. It could thus be deduced that the periodic table was not taught well enough to them although in the post interviews the teacher encouraged teaching of the periodic table before teaching the chemical reactions (Section 4. 2.1 T1 Q4).

Before the learners conducted the practical activity, the teacher read instructions for them. They were required to predict which also took quite some time due to the discussions among the group

members. During the practical activity, group discussions took place. Discussions were both in English and isiXhosa which is the home language (HL) of both the learners and the teacher. The teacher facilitated groups as she moved from one group to the next. Hodson and Hodson (1998) are of the opinion that groups are, in themselves, learning communities, that with skilful teacher guidance and support, can replicate essential features of the scientific community where controversy can promote an active search for more knowledge and better understanding to clarify the precise nature of the dispute.

After they had conducted the practical activity, learners were asked to report their findings. This was done perfectly well in English. Thereafter, the teacher consolidated the lesson focusing on the key scientific concepts to be developed. A summary of the reaction was written on the chalkboard as follows:

hydrochloric acid (Acid) + magnesium + (metal) → magnesium chloride (salt) + hydrogen (gas).

The learners were then given homework.

Lesson 2 (L2)

In lesson 2 (L2), prior knowledge was on the reflection of the L1. Learners were asked to reflect orally and voluntarily on what they observed in L1.

L1: *Yesterday we added acid plus magnesium and got salt and a hydrogen gas.*

T: How did you know the gas is hydrogen?

L5: *When we light it we heard a pop sound.*

T: What else, eh, how did you know that the gas is hydrogen?

L9: *Magnesium joins with chlorine in hydrochloric acid and form magnesium chloride salt and gas in hydrochloric acid was left alone that was hydrogen.*

T: Alright, yesterday we observed that when an acid reacts with a metal a salt and hydrogen gas is formed, today we are going to do an activity on the reaction of an acid with a metal oxide. Can you give me examples of metal oxides you know?

Chorus: magnesium oxide, calcium oxide, copper oxide.

T: Ok that's enough. Our reaction will be on hydrochloric acid and calcium oxide. Here are the activity sheets each group will have one and work as you did yesterday. Don't forget to observe and write down what you see. One other thing you must know that we do not have a Bunsen burner so we will use this stove (holding up spiral two burner hotplate). Start working!

When the first group began working using a stove it was discovered that the plugs in Grade 9 were not working and we had to move to another class. The groups took turns to use the stove until they finished. While the teacher was concluding she was requested to leave the classroom as the period was over. So we went back to Grade 9. She then consolidated the lesson and like the previous day, she gave learners homework and the period was over (see Appendix 6h for their responses and reflections).

Teacher 2 (T2):

Lesson 1 (L1)

Learners were arranged in four groups, three groups consisted of eight members while the fourth group had seven members. Due to the limited resources, the teacher was compelled to have such big groups. Killen (2000) is of the opinion that groups should not be too large or too small. If groups are too large it would be difficult for the group leader to keep them on task and each learner will have limited opportunities to contribute.

On the other hand, if they are too small, one may not get the diversity of opinions and the range of knowledge that is necessary for productive discussions (Killen, 2000). He thus suggests that four or five is the optimal number for small groups. I am raising this about groups because in S2 we took time trying to form groups because their seating arrangement was not in order as some members were at the far end of the table. I suggested a circle shaped seating arrangement instead of the oblong one. All members were close to each other and the activity proceeded.

In contrast to lesson 1 (L1), T2 did not recognize her learners' prior knowledge though in the lesson plan she had stated that learners would be given some revision on acids and bases. Also, groups were not given an opportunity to predict nor hypothesize before conducting the practical

activity. Instead, the teacher read the instructions for the whole class and then she moved from one group to the next giving more explanations where necessary.

All the groups were relaxed and all the learners participated though some learners dominated the groups, especially the boys. Group discussions took place in both English and isiXhosa but when they were reporting, learners used English. Consolidation was done on the board where learners were required to write word equations and then write symbols or formulae and then to balance the equations. Probyn (2004) encourages the use of the chalkboard for recording the main points of the lesson. She confirms that the chalkboard serves as a reference point and provides written language input and support. Finally, the most essential role of a chalkboard is that it can be used interactively with learners.

Lesson 2 (L2)

T2 elicited prior knowledge of learners by letting learners reflect on what happened the previous day.

T: Can anyone from any group tell us what we learnt yesterday?

Learners kept quiet

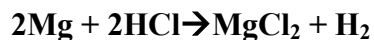
T: Yes class any volunteer please time is against us please say something.

L1: Yesterday ma'am we, we, can I write on the board ma'am?

T: Yes no problem.

L: (Writes on the chalkboard)

Magnesium + Hydrochloric acid → Magnesium chloride + Hydrogen



T: Good, so yesterday we did reaction of magnesium with hydrochloric acid and magnesium chloride and hydrogen was formed. Today we will be doing a reaction of an acid with a carbonate. Each group must come and collect apparatus that are to be used from my table. *Nantsi*

ne activity sheet ne worksheet (Here is the activity sheet and the worksheet). Each group has to use one worksheet please and work together as a group.

Three learners collected apparatus from the table and the teacher explained the practical activity instructions using both languages. The groups started working and the teacher facilitated the activity moving from one group to the next. At the end, group reporters took turns to report (Section 4.2.5b).

4.2.4 Videotaped Lessons

T1 did not conclude the lessons well. Learners just reported and they were not given the opportunity to write the word equations so that they could translate that into symbols or formulae and then balance the equation. Assessment was not done in S1 so the teacher did not determine whether conceptual development and understanding took place or not. To me this is the most crucial step because it is where learners will understand that when an acid reacts with a metal or carbonate, salt and hydrogen or carbon dioxide and water are formed respectively.

T2 did not elicit learners' prior knowledge though she included it in the lesson plan. All the lessons were concluded very well in that learners were required to write the word equation on the board to be seen by everyone and they were also required to translate the information into symbols or formulae and balance the equations at the end. Groups were also required to complete the worksheets in both instances.

The only thing that I saw as a weakness in S2 was that the test for hydrogen was not done in a proper manner where everybody would know how to test for it. Learners were instead required to open the test tube in which the gas was collected and listen to the sound. Only the learner who opened the test tube could hear the sound, others could not hear anything, unlike when one strikes a match and puts it at the mouth of a test tube and a popping sound becomes audible to everyone.

Videotaping was an essential data gathering tool in this study because a lot of discussions emerged while we were watching the videotapes with the individual participants. Reitano (2004) agrees that videotapes give the teacher more time to reflect on classroom events and look for

answers. In short, video stimulated recall allows teachers to reflect and revisit recorded scenes at any time.

4.2.5 Reflections

a. Teachers' reflections

In her reflections, T1 stated that

Being a participant was an eye opener to me. I have gained confidence as the time went by because the reflections after my presentation gave me more strength. My learners enjoyed performing practical activities though we had a problem when we wanted to test for hydrogen gas. In some of the groups, not enough hydrogen gas was collected as a result the expected results were not met.

The teacher also noted that the school needs a science laboratory or alternatively science equipment because when they improvise sometimes the experiments do not give the expected results.

T2 reflected as follows:

How the lesson could have been presented differently? The teacher could have used one metal from the metals chosen in the textbook so that learners get same results. But it also helped to use different metals to give a wide range of results, e.g. they observed that magnesium ribbon reacts faster than zinc.

She further noted that “it is always best to do practical activities because everybody writes what s/he observes. The investigation on the reaction of acids and metals went well” (See Appendix 6i).

b. Researcher's reflections

T1 presented two lessons: reaction of acids and metals (magnesium and hydrochloric acid) and reaction of metals with metal oxides (copper oxide and hydrochloric acid). In the first lesson, T1 recognized learners' prior knowledge. During RPL learners revised reactions of acids and metals. I really appreciated the way the teacher introduced her lessons. Learners were always attentive because the teacher posed questions regularly.

One thing that I did not like was that when learners did not give the correct answers, the teacher would just respond to say the answer is incorrect without letting the learners know why it was incorrect, and then she would simply pass to the next learner who would give the correct answer.

I suggested that incorrect answers should not be left hanging but whole class discussions should be encouraged. The learners may discuss the problem and given time, may come up with a solution. This might also be time consuming but with the intervention of a teacher much time would be saved.

When learners were doing the practical activities, the teacher moved from one group to the next explaining the instructions in the activity. Learners mostly used isiXhosa during their group discussions, but they used English when they were reporting. Groups were not given any worksheets to record their findings but were requested to write their observations at the end of the practical activities. I suggested that learners should always be given worksheets so that they could record their observations as they unfolded because they might forget what transpired if they wrote it at the end of the activity.

I was not satisfied by the way T1 consolidated her lesson because she just instructed the groups to write their findings and then reported and that was all. To me the discussion could have gone further than that. I recommended that the teacher should always write learners' responses on the chalkboard so that they could conclude the activity by writing word equations, symbols and formulae and balance the chemical equations in turns. It is also of utmost importance to make the learners aware of the fact that whenever acids react with metals, salt and hydrogen are produced, and salt and water are produced when acids react with metal oxides. This helps the teacher to pick up whether the learners have understood or whether they still have misconceptions and address those immediately before progressing to the next lesson.

What I liked the most with T1 though, was that she was relaxed when conducting her lessons and this created an environment conducive to effective learning. Even the learners did not regard me as a stranger.

The other debilitating factor that I witnessed with S1 was that there was a gross shortage of resources. As a result, in most cases T1 had to improvise and this somehow disappointed her as the expected outcomes of the activity were sometimes not met. This is one challenge most of our schools experience and it leads to poor learner performance in the Natural Sciences.

T2 presented two lessons, relating to the reaction of acids and metals (magnesium/zinc) and acids and carbonates (calcium carbonate). T2 did not recognize learners' prior knowledge in the

first lesson, but she mentioned something about properties of acids at the end of the lesson. RPL was included in the lessons that followed. The prior knowledge was based on the content of previous lessons.

There were three groups and each group was given a document with instructions as well as a worksheet to record their observations; and then resource people were requested to take the relevant equipment for the practical activity. Learners were actively involved and they were discussing using their language (isiXhosa). The teacher moved from one group to the next to facilitate learning. She always asked the learners in English and they also responded in English.

At the end of the lessons, learners were asked to report to the entire class and this was done in English. As consolidation, learners were asked to write equations, symbols and formulae and to balance chemical equations. Learners were so excited during this session and they were all running to the chalkboard. Even with T2, the incorrect answer was not discussed.

c. Learners' reflections

T1 always encouraged her learners to reflect after each and every lesson. She said she inherited this behaviour from Rhodes University. She recommends these reflections confirming that they assist her a lot because learners are always sincere when reflecting and this helps her to identify learners who have not understood during the lesson and it also exposes gaps in her teaching. The reflections of the groups were as follows:

G1: science easier when we do it practical by the time the teacher told us about these reactions, I did not understand exactly but after this investigation I ganned (sic) a lot.

G2: HCl and H₂SO₄ are blue solution. The molecules of Hcl (sic) disappear and hydrogen and chlorine is formed and the water is formed by two hydrogens and one oxygen. When the water is heated the salt is left behind, i.e., copper chloride.

Conclusion: acids react with oxides to form salt and water e.g. $2\text{Hcl} + \text{Cu}^{\circ} \rightarrow \text{Cuc}'2 + \text{water}^{\text{H}_2\text{o}}$

G3: by the time of this investigation I learnt a lot because I was confusing I think the gas given off was carbon dioxide but now I notice that it is hydrogen. Carbon dioxide is given off when acid react with carbonate, acid react with metal hydrogen is given off and when acid reacts with

oxide water is given off. (Learners' responses are written as they were no corrections have been made).

4.3 Teachers' pedagogical content knowledge (PCK)

The first key component of PCK which is the extent of the learners' understanding and their conception or misconception of the topic helps teachers to interpret learners' actions and ideas as well as to plan effective instruction (Hallim & Mohd-Meerah, 2002). It is recognized that among other things, PCK is a product of the teacher's planning, teaching and reflection on what transpired during teaching and learning practices.

a. Planning

Planning involves a lot of issues that one needs to consider. Developing a lesson plan before going to class is crucial. A lesson plan is a document that guides the teacher in respect of what is to be done before, during and after the lesson has been conducted. In a lesson plan a teacher has to include recognition of prior learning (RPL) which can be learners' background knowledge of the topic or the previous topic they learnt or the strategies that are going to be used.

Thus, for effective teaching and learning to take place this may include practical activities, learners' discussions and language used during those discussions. Resources to be used when a lesson is conducted should be indicated in a lesson plan. Whenever a new concept is introduced, barriers to learning will be expected and so the teacher needs to indicate how they are going to be addressed.

Teachers need to assess the learners to determine their understanding. So, assessment strategies to be used to determine learners' understanding and difficulties should be included in the lesson plan as well as reflections on how the lesson has taken place. That is, was the lesson well-articulated or does it need improvement?

Secondly, planning involves doing research on the topic especially if one is not quite conversant about it. Accessing content from various sources such as the internet, resource books and any materials with relevant information is of great importance before going to class.

With regards to planning, T1 did not include all the components of the lesson plan and as such her presentation did not go as anticipated. Some of the concepts were missing. For example, writing of word equations on the board, translating word equations into symbols and/or formulae and balancing of chemical equations were missing. The conclusion in both instances was lacking. In fact, consolidation of a lesson was not done properly (see Appendix 6h-j).

In contrast, T2 included almost all the components of the lesson plan. I was disappointed though, with her introduction because it was totally different from what was in the lesson plan. When I asked her why, she told me that she was a bit nervous and also the fact that she did not look at the plan before conducting the lesson, had an impact (see Appendix 6k).

b. Recognition of prior learning

In all the lessons, T1 recognized learners' prior knowledge. In the first lesson which was on the reaction of acids and metals, RPL was on acids and metal elements where learners were required to mention the properties of acids and those of metals. The following are the properties of acids and metals respectively as given by learners individually:

Table 3: Properties of acids and metals

<i>Acids</i>	<i>Metals</i>
<i>L1: They are corrosive</i>	<i>L6: Metals are hard</i>
<i>L2: They are sour in taste</i>	<i>L2: They have a metallic lustre</i>
<i>L3: They turn blue litmus paper red</i>	<i>L7: They are shiny</i>
<i>L4: They are below 7 in the pH scale</i>	<i>L5: They are malleable</i>
<i>L5: hydrogen is the common element of all acids.</i>	

Learners were also required to write acids and their formulae on the chalkboard. They were required to mention a few elements orally and then write their symbols on the chalkboard.

Learners were very comfortable with the elements and their symbols and it was evident that the periodic table was taught well.

In the first lesson, T2 did not include RPL at all; learners were just told that they were going to conduct an experiment on the reaction of acids and metals. They were given the instructions and worksheets to complete and each group was required to collect the relevant materials to be used when conducting the practical activities.

Group discussions

Learner and teacher talk should be encouraged in any class (Lemke, 2001). Learners should be allowed to discuss in the language they understand better. The teacher needs to facilitate group discussions to avoid misconceptions that could emerge. It must be borne in mind that some of the scientific terms or concepts have a totally different meaning in isiXhosa in the case of the learners of the two schools. That is why the teacher has to facilitate group discussions.

Setati, Adler, Reed and Bapoo (2002) feel that teaching and learning in a multilingual mathematics and science classroom will be improved if teachers use their learners' main language together with code-switching and they believe that this approach will result in improved and more meaningful discussion between learners in the class. More meaningful discussions in turn are expected to result in better learning and understanding of science and mathematics concepts being taught.

In the context of this study, both teachers adequately facilitated the group discussions. They were moving from one group to the next asking questions and making clarifications where necessary. Learners were in a relaxed mood even those I thought were shy, and were encouraged to participate because every group member was given a role to perform. There were resource people who collected materials from the teacher's table, scribes who recorded the group's observations and the reporters who presented the findings. The roles of the group members were changed the next day. I really appreciated the way both teachers managed the various groups (Killen, 2000).

a. The importance of practical activities

In any science class, practical work is the key because it can provide learners with insights into scientific practice and can increase interest in science and motivation to continue its study (Millar, 2004). Learners remember what they have done easier than what they have been told. During investigation learners remained focused. Skills such as cooperative learning, sharing of ideas, respecting each other's ideas, and observation are encouraged during practical activity.

One group in S1 commented that “*science is easier when we do it practically because by the time teacher told me about these reactions I did not understand exactly but after this investigation I gained a lot*” (see Appendix 6o).

4.4 Concluding remarks

This chapter presents the data on how the two teachers mediated teaching to enhance learners' conceptual development and understanding of chemical reactions. The qualitative data gathered from instruments such as semi-structured interviews, document analysis and lesson observations, are presented in an effort to get a bigger picture of what actually takes place when teachers are teaching chemical reactions in Grade 9.

The data gathered from entirely different sources link the findings to the literature reviewed in Chapter two and will be discussed and interpreted in the next chapter.

Chapter Five

Discussion of findings

5.1 Introduction

Chapter Five presents the discussion of the findings of the study discussed in Chapter Four as well as linking the findings with the literature reviewed in Chapter Two. It is essential that the findings be justified, supported and contradicted if necessary, by linking primary findings with the secondary findings (literature review).

The findings are discussed with a view to answering the following research questions.

- How do Natural Sciences teachers activate background knowledge related to chemical reactions in Grade 9?
- What basic concepts do Grade 9 learners need to know in order to understand chemical reactions?
- Which concepts related to chemical reactions do Grade 9 learners and Natural Sciences teachers find challenging?
- How can Natural Sciences teachers improve the teaching of chemical reactions in Grade 9?

In this chapter I also present the overview of the main findings from my study. The chapter also deals with conclusions and recommendations after research questions and objectives of the study have been revisited. In my evaluation I put forth, based on the findings, suggestions on how teachers can mediate teaching and learning to enhance learners' conceptual development and understanding of chemical reactions in Grade 9. I briefly reflect on the potential value of my study. Finally, I identify some of the limitations of the study and offer some suggestions for future research.

5.2 Interpretation, discussion and analysis of findings

5.2.1 Activation of background knowledge in relation to teaching chemical reactions

The first question of the study, ‘How do Natural Sciences teachers activate background knowledge/prior knowledge related to chemical reactions in Grade 9?’ is addressed here.

In essence, the prior knowledge to which I am referring is what learners are expected to know before they learn, for example, in the context of this study, chemical reactions. It became clear from my study that although the two teachers recognised prior knowledge and learning of learners, they tended to neglect eliciting prior knowledge on some of the concepts that are the foundation for the meaningful understanding of chemical reactions. This resulted in learners having had challenges in understanding concepts embedded in chemical reactions. For example, concepts associated with the periodic table, chemical bonding, balancing of chemical equations *etcetera* before dealing with chemical reactions were not adequately elicited so that learners could understand them meaningfully.

However, both T1 and T2 indicated that they were aware of the importance of recognition of prior knowledge and learning. For instance, in their lesson plans T1 mentioned that she would ask questions on acids while T2 indicated that she would do revision on acids and bases. It seems it is easier said than done.

As mentioned above, T1 included background knowledge in all her lessons but did not include the basic concepts that are suggested to form prior knowledge in chemical reactions. However, this really helped her learners to quickly understand the new concepts as they were linked nicely with what they had already learnt from the previous lessons. The first lesson was on the reaction of acids and metals and as introduction, learners were asked questions on acids and metals. For instance, the following questions were asked from learners to probe their prior knowledge:

Q1: What are the properties of acids?

Q2: Give examples of laboratory acids and write their formulae on the chalkboard.

Q3: What are the properties of metals?

Q4: Give any four metals you know and also write their symbols on the chalkboard.

When learners were answering the above questions, a lot of relevant ideas that linked the lesson to be presented with what the learners already knew emerged and this made the lesson meaningful. The importance of asking and answering questions as a means of eliciting prior knowledge is also suggested by Rowe and Rayford (1987). They suggest that teachers can facilitate learners' activation of background knowledge by having them answer questions before and/or while they learn new material. It has been theorized too that generating answers to questions facilitates deep processing and high level knowledge construction which in turn facilitates learning (King, 1994; Pressly, Wood, Woloshyn, Marti, King & Menke, 1992).

On day two, T1 elicited background knowledge by letting her learners reflect on what they had learnt the previous day. Furthermore, learners were also required to make predictions (Maselwa & Ngcoza, 2003) about what gas was to be liberated when a metal oxide reacts with an acid by merely looking at the chemical formulae of the reactants. On the same note, Millar (2004) warns us that predictions are of course, only valuable if they are more than mere guesses, and are derived from ideas about the situation. So, learners had to first recall information on the formulae of the compounds and only thereafter they predicted.

It is also recommended that teachers should always keep on referring to the periodic table whenever they are dealing with chemical reactions so that learners would see the relationship between the reactants and the products. I believe that this will make things easier for learners when they get to the balancing of the chemical equations. In essence, in my observation I discovered that although the two teachers did not include elicitation of prior knowledge quite satisfactorily, they were aware of its importance (see Section 4.3 b).

For instance, T2 did not elicit prior knowledge during her first lesson but she however incorporated it during her second lesson. When I asked what made her elicit learners' prior knowledge in lesson 2, she responded as follows:

You know ma'am, yesterday I was a bit nervous. I indicated in my lesson plan that I would let the learners answer revision questions on acids and bases but *ndalibala ndizokukhumbula xa ndiqukumbela ilesson yam* (but I forgot and remembered when I was wrapping off my lesson). Today I was much more confident. The other thing that encouraged me not to forget today are the reflections that took place yesterday.

I appreciated the honest reflection by T1 as it clearly indicated that sound relations and trust between us were emerging. Also this shows the potential value of reflections after observations. As far as reflections are concerned, T1 also afforded her learners an opportunity to reflect on what happened in the previous day.

With both teachers, incorrect answers were not discussed by the groups. Instead, they were just left hanging. To me this can create misconceptions as learners will not know the correct answer if it is not discussed by the whole class together with the teacher. In our debriefing session I suggested to the two teachers that it would have been useful if the incorrect responses were discussed during their lessons and could have helped to enhance discussions and learner talk (Lemke, 2001).

Zhang (2008) too suggests that talk is arguably the true foundation of learning. He further points out that some teachers apply two kinds of classroom talk which have greater potential discussion and scaffolding dialogue. The former, existing between teacher-class, teacher-group or learner-learner, means the exchanging of ideas in sharing information and solving problems. While the latter refers to achieving common understanding through structured and cumulative questioning and discussions which guide and prompt, reduce choices, minimise risks and errors and expedite handover of concepts and principles.

Nonetheless, the use of a chalkboard to consolidate scientific concepts by both teachers was commendable and encouraged. Writing summaries on the chalkboard and letting learners write their answers such as formulae, symbols and balancing of chemical reactions on the chalkboard enabled even the slow learners to catch up and be on par with others. Learners were also able to take notes and refer to those notes at home so as to remind themselves on the topic taught. Czerniewiecz, Murray and Probyn (2000) argue that a chalkboard can be a useful learning and teaching support item if it is used appropriately.

Furthermore, with reference to learning and teaching support materials such as textbooks, they also need to include the elicitation of prior knowledge. Yet, in the textbooks used by the teachers and learners in this study, elicitation of prior knowledge seems to be very scanty. Learners are simply reminded of what they learnt from the previous lesson and that is all. There are no activities that probe learners' prior knowledge whatsoever. This lack of strategies to elicit

learners' prior knowledge thus requires teachers to formulate their own questions as a means of elicitation of prior knowledge.

5.2.2 Concepts that teachers need to consider when teaching chemical reactions

a. Reactivity of substances

The two teachers did not mention anything about reactivity when they were teaching the chemical reactions and yet as far as I am concerned this is very important. Even though I observed two lessons from each teacher, it was clear that they were not going to mention reactivity because I managed to have an opportunity to look at their lesson plans where they planned for the three lessons they were going to present and found out that reactivity was not included (Appendix 6g).

b. Reactants and products

Both T1 and T2 in this study were aware of the importance of these concepts. Learners were from time to time asked about these concepts, whenever a chemical reaction was written on the chalkboard, teachers would ask which substances were the reactants and which ones were the products? The response of both school 1 (S1) and school 2 (S2) learners was always correct. The textbooks that were used in both schools too indicated reactants and products in all the reactions (Section 4.2.1d).

c. Particle model of matter

Nothing was mentioned about the particle model of matter by both the teachers. Learners were simply required to present their findings and then write that on the chalkboard, that was all.

d. Chemical Bonding

T1 and T2 did not mention anything with regards to chemical bonding. When I asked them why they did not even say a single word involving bonding they responded as follows:

T1 had already taught her learners chemical bonding in the first term under the topic 'chemical reactions at microscopic level' and did not think that it was necessary to include it during her lessons. She said that her learners understood chemical bonding very well. When asked about the

assurance of her statement, she said that she was not sure if they still remembered anything on chemical bonding but what she knows was that they understood it then.

T2 also told me that she last mentioned chemical bonding in the first term. She said that including chemical bonding in the lessons she presented was going to derail her as that is a lesson on its own.

I suggested to both teachers that it would have been useful if they had included chemical bonding in the elicitation of prior knowledge as a revision so that learners could see the relationship between chemical bonding and chemical reactions.

e. Elements and their symbols

The above concepts are supposed to be dealt with when teaching the periodic table. T1 and T2 confessed to me that they never taught the periodic table in detail. They just made mention of key things such as the groups, atomic number and atomic mass only.

f. Compounds and their formulae

Learners in both schools were required to observe any colour change that would take place when acids reacted with different substances. They also indicated whether the product formed was a gas, solid or liquid. T1 and T2 did not mention the fact that the products formed were compounds and/or elements. Both teachers did not explain to the learners what chemical changes the reactants underwent in order to form different substances altogether. For example, an acid which is in a liquid state reacts with a metal which is in a solid state to produce totally different substances such a salt and hydrogen gas.

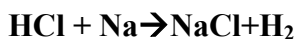
It would have been useful if T1 and T2 had explained this to their learners. A teacher may show this reaction using a variety of methods to create an imaginary picture (microscopic view) to the minds of the learners. It should be remembered that learners do not see what takes place when the reactants form products; they have to imagine the process. That is why the teacher should take it further and show their learners what happened during a chemical reaction using models and/or analogies. It is suggested that models be used extensively in science as representation of something that cannot be observed directly. Johnstone (2010) warns us that models and analogies should be used bearing in mind their limitations.

5.2.3 *Chemical reaction concepts that learners and teachers find challenging*

a. Balancing of chemical equations

Both T1 and T2 confirmed that learners had difficulty in the balancing of chemical equations. They both confirmed that they do not know which strategy to use when teaching balancing so that learners could understand it better. Even with their worksheets, learners showed that they were struggling with the balancing of the equations. For example, learners were asked to balance equations on the chalkboard and it was evident that most learners still had difficulties with this.

Very few learners understood this concept. For example, most learners balanced the chemical equation as follows:



Instead of doing it like this: $2\text{HCl} + \text{Na} \rightarrow \text{NaCl} + \text{H}_2$ they wrote $\text{H}_2\text{Cl} + \text{Na} \rightarrow \text{NaCl}_2 + \text{H}_2$.

This suggests that learners did not understand the chemical reactions at microscopic level which according to the Grade 9 work schedule is taught in the first term as an introduction to the chemical reactions.

5.2.4 *How can teachers improve the teaching of chemical reactions in Grade 9?*

a. Practical activities

During the pre-interviews, both teachers highlighted the importance of practical activities in teaching science. They both stated that learners understood better when they do practical activities. Millar (2004) too agrees that encouraging learners to pursue their own enquiries taps into their natural curiosity. He further states that finding things out for yourself, through your own efforts, seems natural and developmental, rather than coercive, and may also help you to remember them better.

Furthermore, during practical activities, learners acquire scientific skills such as observing, testing, making predictions, hypothesizing, recording, analysing data and making conclusions (NCS Policy Document, 2002). Even S1 learners in their reflections mentioned that practical work helped them see science with new eyes. In one of the groups there was a comment that before a practical activity was done, learners were confused, but after they had observed and

tested the results they were no longer confused. They were now sure of the results as they had found out through conducting the experiments on their own (see Appendix 6g). When learners were conducting the practical activities they were enjoying it and were focused. All the groups were actively involved. The teachers facilitated practical activities very well.

There is however a common challenge that faces the majority of schools which also affected S1, that is, the lack of science equipment. This hampers the improvement of science teaching and learning because the expected outcomes sometimes are not met. It happened in S1 when learners had to use a hot plate instead of spirits lamp or Bunsen burner and they had to take turns to use the equipment. As such the practical activity was nearly a disaster but the teacher managed to explain what could have happened if all was well (Appendix 6f).

The two teachers also complained that their schools had no science laboratories or science classrooms. They said that they always experienced problems when conducting practical activities in ordinary classrooms because they needed a long time before they reach the conclusion. They said what usually happened was that the period would come to an end whilst they are still in the middle of the experiment and they would be forced to stop and pack up their equipment without reaching the conclusion. They said that this really confused the learners who sometimes seemed to have forgotten what they had previously learnt, such that one has to start from the beginning to explain what had been done the previous day. So, a lesson that was planned to take two periods ended up taking four or more periods and that is also exacerbated by the extensive NS syllabus as it includes four themes that are comprised of five subjects.

b. Language used when teaching and learning takes place

The language of learning and teaching (LoLT) from Grades 4 to 12 in most of the schools in the Lady Frere District is English, yet as we have seen, English is not the home language of the learners in this area. Instead, their home language is isiXhosa. Again science has its own language which differs completely from everyday language spoken at home or social surrounding; this encourages teachers to code-switch especially when introducing a new concept in order to clarify it. Setati and Adler (2001) feel that the practice of code-switching is supposed to ensure that the amount of the use of the language of instruction increases in the classroom and

that there is transfer of understandings of science and mathematics concepts from one language to the other.

The two teachers took cognisance of the fact that LoLT (English) is not the language of the learners so they code-switched during their facilitation. The two teachers used code-switching cautiously when they were presenting their lessons and when they were explaining instructions for the practical activities, but when they were moving from one group to the next, both teachers communicated with the learners in their home language. Learners were allowed to discuss in their home language too, but they used English to present their findings and to answer questions asked by their teachers.

During the observation I noticed that even teachers confused some of the concepts. For example, T2 said “*let us mix an acid and a metal*”. This statement is scientifically incorrect but it makes sense in the language context. Learners can confuse a mixture and a compound because they will think that what is formed from the reaction of an acid and a metal is a mixture as they were required to mix the two. This means that teachers themselves should be very careful not to create misconceptions by unconsciously confusing terms.

5.2.5 Use of a variety of teaching and learning strategies by teachers

The use of relevant and various teaching and learning strategies depends on whether or not the teacher has adequate and appropriate pedagogical content knowledge, because then s/he will know which strategy to use, and when and how to use that strategy effectively.

In all schools learners are diverse; they have different levels of understanding so it is the role of a teacher to use different teaching and learning strategies so as to make learning meaningful. Strategies such as practical work, co-operative learning, and science discourse were used effectively by the two teachers. Although all the above-mentioned strategies take a long time, learners enjoy learning when they conduct practical activities. They become responsible for their learning if they are involved in co-operative learning and class discussions. In fact, the whole idea encourages constructivism which is one of the theoretical frameworks underpinning my study (see Section 2).

The two teachers in my study used a variety of teaching and learning strategies trying to mediate learning in order to enhance learners' conceptual development and understanding. Below follow the strategies that were used by the two teachers.

c. Science discourse

Both T1 and T2 encouraged the learners to present their findings after each and every practical activity that was conducted. However, a limitation was that learners were not given an opportunity to discuss their presentations. Giving learners time to discuss their presentations can assist the teacher to close the gaps that other learners might have because each class has a diversity of learners, some understand faster than others. Letting learners present their findings without discussing them may leave some of the learners with misconceptions. Teachers need to facilitate these discussions to avoid learners talking out of context or taking a longer time without reaching consensus. Although the environment was conducive for the learners to ask questions, they did not ask any questions from the teachers which clearly shows that they were not used to that.

d. Collaborative learning

In both schools collaborative learning took place. Learners conducted practical activities in groups and every member was obliged to participate as they were assigned to specific tasks such as recording, collecting equipment and presenting. Furthermore, roles of members were changed from time to time (Killen, 2000).

When they were busy with their practical activities, learners were deeply engaged in discussions (Ramsden, 1994; Maselwa & Ngcoza, 2003). I noticed that these learners were used to this activity because they were taking turns to talk and members' ideas were respected. That is, each learner was given time to talk while others were listening. The scribes were required to read their notes to the members so as to verify the correctness of the statements. During presentations, other members of the group assisted where necessary. This was quite interesting because it indicated that teachers now know how groups are made to be functional, they no longer form groups for compliance but for effective teaching and learning.

Both T1 and T2 facilitated group activities very well by moving from one group to the next leading their learners to new discoveries. They moved around the groups giving explanations

where necessary and helping their learners to develop an understanding of scientific concepts. Constructivism encourages facilitation rather than teaching. Brooks (1990) states that a facilitator promotes dialogue between learners, helps learners to elaborate upon their ideas, challenges learners' thinking by presenting contradictions to their ideas without demeaning them as people, uses wait-time after questioning learners, promotes inquiry by learners through questioning them and having them question one another, provides time for learner processing and thinking and identifies students' conceptions and misconceptions.

Killen (2001) too is of the opinion that it is inevitable that there will be some disagreements between learners working in groups. Even though a teacher (facilitator) may have spent time developing their communication skills and stressing the importance of accepting all ideas and opinions, some conflicts will inevitably arise. So, a facilitator has to intervene to help learners turn these conflicts into constructive learning experiences.

5.2.6 Pedagogical content knowledge

With regards to PCK as defined in Section 2.4, the two teachers may lack some of the skills such as curriculum knowledge because of the changing curriculum since 1994. T1 did not do any science subjects in high school and at the Teachers' College but was employed and expected to teach Natural Sciences (NS) from Grades 7 to 9. As a dedicated teacher she started networking with other NS teachers around her so as to gain knowledge around the new field. According to T1, this has helped her a lot in that she managed to produce learners who when she followed their trend at high school performed quite well in Physical Sciences as well as in Life Sciences. She also gained experience from Rhodes University (RU) where she acquired an ACE in Science Education.

In essence, T1 does not seem to have a lot of gaps in science content and pedagogy. She has attended workshops regularly so that she could be on par with her counterparts in as far as subject matter knowledge and pedagogical content knowledge were concerned. Her learners were quite active; it was evident that they had confidence in their teacher. She always received feedback from her learners through their reflections which they were expected to write after every lesson. I can mention that she does not have enough experience to deal with certain

challenges such as lack of science equipment. At some stage in this study learners had to improvise because of a shortage of equipment and it was disaster (Section 4.2.2). Be that as it may, T1 is a very dedicated teacher who is respected by her learners.

In contrast, T2 has sufficient science content knowledge as she has specialized in Physical Sciences at high school and in teacher training college. She too acquired an ACE in Science Education from Rhodes University. At Rhodes University she developed in both subject matter knowledge and pedagogical content knowledge. This was quite evident in her presentations as she was confident and kept dealing with misconceptions immediately. Furthermore, her teaching experience is helping her a lot because she tackles challenges such as shortage of science equipment wisely. For example, she did not have calcium carbonate at all and she managed to use alternative substances such as chalk and lime instead and got the expected outcomes.

Both teachers confirmed that NS workshops and continuous assessment moderation that they attend time and again are very useful as they develop them pedagogically and content-wise. They said that when they attend the above activities teachers in the cluster share ideas on how to tackle some of the challenging concepts. They also develop assessment tasks so as to standardize assessment in schools and since some teachers are more knowledgeable than others, they explain the challenging concepts so that everybody is on a par and also encourage one another to try and cover the syllabus.

5.3 Critical reflections on the study

The main focus of education is on teachers getting a clearer understanding of how children learn, and how learning with understanding can be achieved in any subject or learning area, Natural Sciences in this case. Both general literature and the National Curriculum Statement (NCS) reveal that the contribution of practical work (Maselwa & Ngcoza, 2003; Millar, 2004), sufficient pedagogical content knowledge (PCK) of teachers (Shulman, 1986, 1987; Lounghran, Milroy, Berry, Gunstone & Mulhall, 2000), elicitation of prior knowledge (Rowe, & Rayford, 1987) and learning a variety of teaching and learning strategies could improve learning with understanding. These help the learners to connect what they know from the real world to the knowledge they are expected to build up in school in a meaningful way.

It stands to reason therefore that if teachers have sufficient subject matter knowledge and PCK, teaching and learning of Natural Sciences in general, and chemical reactions in particular can be improved drastically. That would bring us closer to the desirable changes for our reformed South African classrooms. This suggests that PCK is the foundation of teaching and learning. Shulman (1986) included PCK in what he called, 'the knowledge base for teaching'. This knowledge base according to Shulman (1987) consists of seven categories, three of which are content-related and the other four categories refer to general pedagogy, learners and their characteristics, educational context and educational purposes.

5.4 Recommendations

It is of utmost importance that principals allow teachers to remain teaching the same learning areas especially Natural Sciences as this helps them to develop and become knowledgeable in the content and PCK of that particular learning area. As PCK is considered the base for teaching, it is recommended that student teachers in colleges have a module on PCK.

Science teachers need to upgrade their level of education in science content and pedagogy so that they could be developed in all the aspects of their subject or learning area. They also have to attend workshops regularly so as to attain the required skills and content knowledge. This means that Subject Advisors should conduct workshops on a quarterly basis at least, in order to deal with content knowledge for that particular term. This will enable teachers to know exactly what and how to teach in that term.

It is suggested that teachers should always recognize learners' prior knowledge and learning linking it with what they will be learning. This encourages progression within a learning area. For example, you cannot teach chemical reactions without having taught your learners the periodic table and the other relevant concepts.

Teachers need to be helped to work effectively within the current constraints of the language of learning and teaching (LoLT) English which is the second language of the majority of learners in South Africa. There is therefore a need for training teachers in order to equip them to deal with teaching through the medium of a second language.

Textbooks used in schools should address all the concepts in chemistry thoroughly because currently, all Grade 9 textbooks have insufficient information on the periodic table, chemical bonding, and particle models of matter.

All schools need to have science laboratories or alternatively science classrooms in order to perform practical work effectively and with minimal disruptions. Schools should prioritize and procure science equipment. Without relevant teaching and learning equipment, the teaching of chemical reactions can be a disaster and practical work compromised.

The other most important aspect that teachers should consider is the proper planning of lessons before conducting them. Planning includes preparing the equipment needed, researching relevant content from various sources such as resource books, the internet and experts in that learning area. Good planning gives a teacher the confidence to stand in front of his/her class for meaningful teaching and learning. Learners will gain confidence in their teacher and develop a love for the subject such that their performance will be considerably improved.

5.5 Limitations of my study

One of the limitations to the study is that the two teachers that have been purposefully selected for this study do not represent the whole population of Grade 9 teachers in the Lady Frere District and therefore the findings cannot be directly generalized to the larger population. Maybe a reference to where this was stated earlier will suffice.

Time was another limiting factor of my study. Both my research participants and I were sometimes unable to meet as scheduled. As a result, we started our meetings later than the times we had agreed upon. It sometimes happened that when I was free to meet them, they were busy with other departmental programs in the learning areas they offered other than Natural Sciences. Programs such as workshops, Continuous Assessment (CASS) moderation and examinations are the standing programs which usually take a long time.

There is also the Integrated Quality Management System (IQMS) programme which takes place yearly to determine the performance of all teachers. Furthermore, extra-mural activities consume a lot of time and they sometimes even impact on tuition time. It also happened that when the

participants were available, I was busy with my programmes. So, this hindered the progress of my study and hence put more pressure on me.

The colleague who let me down with the videotaping of the lessons also affected my study because I missed some of the points as I was also taking notes whilst videotaping. I also experienced challenges with regards the video recording as I could not find a proper video recorder. I decided to use my mobile phone. I tried to download the video to my laptop so that we could have a better view but there was no sound and this further hampered the momentum of my study in that we had to watch the video on a mobile phone.

5.6 My personal reflections

Doing this research has converted me in many ways. The study has broadened my scope of thinking and has thus changed it.

Before conducting the study, reading was not my hobby but now I can't sleep without having read a paragraph or two because without reading one will never succeed in this field. As a Subject Advisor I have gained a lot from the readings I came across and as such have developed in many aspects of education in general. My perception has changed from that of an ordinary person to that of an academic.

Having observed teachers I was touched by the manner they do things under the difficult conditions of the poorly equipped schools. Teachers are working under pressure to make learning meaningful in their schools. I even understand why teachers are always stressed especially those who are not learning area or subject specialists as they lack pedagogical content knowledge which is the basis of teaching and learning practices as I have discovered from the literature I came across in my study.

Through this study, sound working relationships have developed between the participants and me. They are now free to voice out their concerns and suggestions and they frequently come to the office to be advised or even invite me to come to their schools for assistance, unlike before the study where they would wait for me to visit their schools. I agree that this has happened with just a few teachers but I hope that with time it is going to spread to others as well.

I also learned that collaborative learning does not end in the classrooms; it continues even with other students doing a degree, and I have seen its advantages. Supporting each other as students helped me a lot since the students with whom I studied were more advanced than I was, but through working hand in hand with each other I improved.

I have also realised the importance of having one's own equipment such as a computer or even better a laptop, because you can carry it everywhere you go and you can work whenever you get the opportunity to do so. A 3G card or modem to access information from the internet, video recorder as well as accessories such as a printer and flash disks to store information are invaluable. Being computer literate is one of the skills that a researcher has to acquire especially in this technological era. Technology hastens communication processes and it is so easy to communicate with your supervisor and other people involved in your research.

5.7 Concluding remarks

In this chapter I have discussed the findings of the study with respect to its aim of investigating how Natural Sciences teachers mediate learning in order to enhance conceptual development and understanding of chemical reactions in Grade 9. The analysis and interpretation done in this chapter has responded to the four research questions as posed in the beginning of the study. This has revealed that teachers in this study strived to accomplish education goals irrespective of the challenges facing them. The most prominent challenge is the absence of laboratories or alternatively science classrooms and the shortage of science equipment in schools.

On the basis of the above, conclusions have been drawn and recommendations made about how Grade 9 teachers mediate learning to enhance learners' conceptual development and understanding of chemical reactions.

Finally, it is suggested that teachers need to be able to develop their own learning and teaching support materials (LTSMs) for effective and efficient teaching. This is a potential future research project.

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APPENDICES

APPENDIX 1

Letters to two Principals

PO Box 276

Cala

5455

09/09/2010

The Principal

Mfundisweni JSS (pseudonym)

5410

Dear Sir/Madam

RE: Request to visit Natural Sciences (NS) Grade 9 teacher Mrs Sibotoboto (pseudonym)

I am Ms B. Xipu, a Subject Advisor for Natural Sciences (INTERSEN) at Lady Frere District. I am currently doing Masters' Degree in Science Education at Rhodes University. My research topic is: An investigation of how Natural Sciences teachers mediate learning in order to enhance conceptual development and understanding of chemical reactions in Grade 9 learners.

In my study I am expected to select a few teachers to participate in the research. It is therefore a great pleasure to inform you that I have selected your school as one of the schools that would be of great assistance to me in investigating the above mentioned topic.

With regards to the above information I therefore humbly request to visit your NS teacher **Mrs Sibotoboto** as one of my participants. I would like to put to your attention that the teacher concerned will be expected to present lessons in the course of the study so this implies that my visits will at least take more than an hour. I am intending to pay three visits at your school. The first visit is intended to be on Monday the 14th of February 2011. We will negotiate with the teacher in connection with the other visits. I am prepared to do whatever is going to suit her so not to inconvenience her.

I also would like to assure you that the information gathered from the school will remain confidential unless mandated by the school to divulge it.

I hope that we will have good working relations from now till the end and beyond this study.

Yours truly

Ms B. Xipu (0835848908)

PO Box 276

Cala

5455

09/09/2010

The Principal

Esidubini JSS (pseudonym)

Lady Frere

5410

Dear Sir/Madam

RE: Request to visit Natural Sciences (NS) Grade 9 teacher Mrs Bongani (pseudonym)

I am Ms B. Xipu, a Subject Advisor for Natural Sciences (INTERSEN) at Lady Frere District. I am currently doing Masters' Degree in Science Education at Rhodes University. My research topic is: An investigation of how Natural Sciences teachers mediate learning in order to enhance conceptual development and understanding of chemical reactions in Grade 9 learners.

In my study I am expected to select a few teachers to participate in the research. It is therefore a great pleasure to inform you that I have selected your school as one of the schools that would be of great assistance to me in investigating the above mentioned topic.

With regards to the above information I therefore humbly request to visit your NS teacher **Mrs Bongani** as one of my participants. I would like to put to your attention that the teacher concerned will be expected to present lessons in the course of the study so this implies that my visits will at least take more than an hour. I am intending to pay three visits at your school. The first visit is intended to be on Monday the 21st of February 2011. We will negotiate with the teacher in connection with the other visits. I am prepared to do whatever is going to suit her so not to inconvenience her.

I also would like to assure you that the information gathered from the school will remain confidential unless mandated by the school to divulge it.

I hope that we will have good working relations from now till the end and beyond this study.

Yours truly

Ms B. Xipu (0835848908)

APPENDIX 2

SEMI-STRUCTURED INTERVIEWS

Teacher 1

1. Did you specialize in Science?

I could say yes because I did Science in standard 10 and I have Advanced Certificate in Education (Maths and Science) at Rhodes University.

2. How does the experience you have in teaching assist you in teaching chemical reactions?

I do not have much experience because after passing my education diploma I stayed at home until 9 years ago when I started teaching but I have gained experience through workshops where we are advised how to teach certain topics. We also go for moderations where teachers share ideas on the content and methodology.

3. What documents do you use when teaching NS?

I use prescribed work schedule from the Province, lesson plans also from the Province, learner's book (Science Today) and Spot On as an additional resource book.

4. How do you introduce chemical reaction? Why?

I start by teaching periodic table though it is revision, one has to teach it well especially the first twenty elements learners must know them by heart. The periodic table helps me a lot; it is where chemistry starts.

5. Is it easy or difficult for learners to understand chemical reactions? Why?

It is not easy because we do not have science kit we last have it from Science Education Project (SEP). When we are doing experiments sometimes we do not have enough resources and I improvise but we sometimes do not get the expected results of the experiment.

6. What challenges you when teaching chemical reactions?

The fact that we do not have enough science equipment is a big challenge to me as I have indicated that we improvise and sometime we do not get the expected results of the experiment.

Teacher 2

1. Did you specialize in Science?

Yes. At Matric I did Science subjects such as Biology, Mathematics and Physical Sciences. At the teacher training college I specialized in Mathematics and Physical Sciences. I also acquired Advanced Certificate in Education specializing in Mathematics and Science at Rhodes University.

2. How does the experience you have in teaching assist you in teaching chemical reactions?

I have 20 years of experience in teaching, since then I have been teaching what was called General Science which is now known as Natural Sciences. So with such experience I know the topics that challenge learners within chemical reactions and I have my ways of addressing those areas immediately to avoid misconceptions.

3. What documents do you use when teaching NS?

I always start from the **work schedule** because it tells me what topics to teach on a weekly basis. From there I go to the learner's book and teacher's guide (Spot On) to get the activities. To get more information I refer to the modules I got from Rhodes University they are so informative, they help me a lot. I also use other resource books like Oxford Natural Sciences and Shutter's Natural Sciences.

4. How do you introduce chemical reactions? Why?

It depends which topic am I gonna teach but I usually begin with the periodic table because to me the periodic table is the foundation of all chemistry.

5. Is it easy or difficult for learners to understand chemical reaction? Why?

Learners are able to understand when they do practical activities but when you assess them it becomes a problem more especially with reactants, products and balancing of chemical equations.

6. What challenges you when teaching chemical reactions?

No laboratory so you have to be fast so as to give space for the next teacher and you cannot even set your apparatus in time. So the period of 60 minutes is too short when you are going to do practical activity like experiment. You know madam I was impressed at RU because during Science classes we always come to find out that the apparatus were already set for us.

APPENDIX 3

FIELD NOTES

Teacher 1 Lesson 1- reaction of a metal (Sodium) with an acid (Hydrochloric Acid)

Classroom has a periodic table and other NS charts hanged on the wall, it is a living classroom not a church.

Recognition of prior knowledge on the properties of acids and metals was lengthy but appreciated.

Almost all the learners know metals and their properties. They also know the symbols of the elements they were using in the investigation. With the formulae some of the learners are experiencing problems when writing them, I notice that especially with group 2 learners. This needs to be addressed urgently. In actual fact the teacher needs to teach the periodic table thoroughly so that the learners can be comfortable with writing and identifying both the symbols and the formulae.

I was impressed by the way the learners recall the properties of acids. It became evident that acids were taught thoroughly to these learners.

The teacher read the instruction for the learners. I wish that learners be given opportunity to read instructions on their own then the teacher could explain when they do not understand. Learners should be encouraged to work independently. This will help them to be problem solvers in future.

Learners were required to predict before conducting the investigation. This impressed me because it showed that the teacher is aware of the steps for investigation.

Learners seemed to enjoy practical activity. Everybody was fully engaged. This indicated that it was not the first time for them to do practical work. Their discussions were in both English and isiXhosa, but it was mostly in isiXhosa. The teacher moved from one group to the next, she was sometimes called by the group to explain the instructions.

Learners were reminded time and again to record their observations on a piece of paper. They tend to forget that they were supposed to record their observations, had they were given a worksheet, this was not going to be the case. So a worksheet play a very important role during an investigation as it reminds learners what to observe.

Groups gave reports in turns. There were no discussions this time. Incorrect responses were not discussed at all. This can create misconceptions to learners. Whole class group discussions are important for clarification purposes.

I was expecting that when consolidating the lesson, learners would be required to write a chalkboard summary on the word equations, chemical equations and balancing but that did not happen. Having looked at their records, I discovered that some of the learners really struggling to write symbols and formulae correctly especially when a symbol has two letters of the alphabet.

Teacher 1 Lesson 2- reaction of a metal oxide (Copper Oxide) with an acid (Hydrochloric Acid)

Today the prior knowledge is on the activity conducted the previous day. Learners were required to reflect. This was a very interesting session. Their reflections went as follows:

L1: ‘When acid reacts with metals, salt and a gas is liberated’

L2: ‘Some metals react with acids but not all,’

L3: ‘In our group we were confused we thought that the gas released was carbon dioxide because there was a bad smell but now we know it is hydrogen because when we tested for it it burns with a popping sound.’

Discussions took place on what transpired from learners’ reflections. When they were reflecting, learners strictly spoke English; there was no compromise. I was very impressed by this because English is the language of learning and teaching so learners need to be encouraged to express themselves in English so that they are not stuck when assessed.

Today all did not go well. We do not have all the required apparatus so we will have to improvise. For example there is no spirit lamp so a hot plate will be used instead, a saucer for evaporating dish and a strainer for a filter paper. The plug is not working properly in this classroom so we have to shift to grade 3 class room. Four groups had to share the apparatus. This whole process consumed a lot of time and learners seemed discouraged while their teacher looks very worried and disappointed. I am not sure whether this trouble would be taken if I was not there. It might happen that when cases like this occur, teachers become discouraged and take no trouble but simple theorize.

All the same the lesson was conducted and learners took turns to investigate until they were through with their observations. Groups were required to report.

G1: ‘We noticed that copper oxide sinks, small bubbles on the side to side, the colour changed to blue and some particles remained.’ At this moment the teacher was called and she came back telling me that the classroom is needed and we had to go back to grade 9 classroom.

So only one group reported because our time was over and when we got to grade 9 class the period was long over so the teacher consolidated and gave the learners home work.

Teacher 2 lesson1- reaction of a metal (Zinc/Magnesium) with an acid

Recognition of prior learning (RPL) not considered by the teacher. T2 told her learners that they were going to do an experiment on the reaction of an acid and a metal ($\text{HCl} + \text{Mg}$), and then the learners were just given an activity sheet and were required to collect the relevant equipment from the science kit in front of the class. A worksheet to record their observation was also distributed. Each group was expected to use one worksheet for the whole group. Cooperative learning was thus encouraged. Each group was expected to have the resource person to collect the equipment and to pack it back after use. In fact all the groups had a resource person, a scribe and a presenter.

When the experiment was conducted, learners were discussing and the teacher moved from one group to the next. She was sometimes called by the group to explain something or she just went to any group to facilitate the activity. Learners were discussing in *isiXhosa* all the way. The teacher explained in both *isiXhosa* and English.

Groups were required to report their findings by reading their responses from the worksheets. The teacher then consolidated the lesson. In conclusion, learners were required to write word equations of the reaction, and then they had to write the symbols or formulae and at the end balance the chemical equations. Learners were asked to do all the above voluntarily on the chalkboard. At the end the teacher concluded by mention that magnesium is highly reactive compared to iron that means it react faster with an acid than iron.

Teacher 2 Lesson 2-reaction of an acid (Hydrochloric Acid) and a carbonate (Copper Carbonate)

Learners are already in groups. Prior learning was considered today. Learners were asked questions about what they learnt the previous day. They answer the questions in groups. The teacher tells the learners that today they are going to conduct an experiment on the reaction of an acid and a carbonate. Resource people collect the equipment from the table and learners started conducting the experiment. They discuss and the teacher facilitates moving from one group to the next just like yesterday. Clear lime water was used to test the gas liberated.

After they have finished, presenters report the findings. They are required to write word equations, symbols and/or formulae on the chalkboard and then balance those. Finally, the teacher consolidates the lesson telling the learners more about carbonates giving more examples such as chalk and limestone.

APPENDIX 4

My journal

It was towards the end of 2009 when my supervisor Dr KM Ngcoza approached me to consider doing Masters Degree in Science Education in 2010. I was reluctant at first but with time I decided to grab this life time opportunity and accepted the offer. Below is a summary of the road through my project research and I would like to tell people that doing a research needs a lot of dedication and commitment because it is not a plain sailing it has got undulations and meanders just like the Amazon River flowing across South America.

12/02/10 was my first day to meet with my Supervisor Dr KM Ngcoza and other four students. Dr Ngcoza wanted to know our projects and I was a bit stunned as I was still not aware of what we were going to do this week. But be that as it may I manage to say something. I was threaten when I discovered that the other two students were a bit ahead of us as they stay in Grahamstown so they already have met with Dr Ngcoza to discuss some of the issues concerning their projects.

13/02/10

Things are becoming clearer a bit today. I think I was a bit exhausted yesterday because I drove all the way from Cala to G'stown. We discussed the homework we were given; discussions were interesting and eye-opener.

14/02/10

I'm more comfortable today because I have done the reading and I am getting to understand what is expected of me. I could sense that Dr Ngcoza was a bit worried about me, I think he has noticed that I'm not But today I told him that I have gained momentum. We were given an assignment to write and I'm prepared to work hard on it.

16/02/2010

Visitor Lesley Masters Degree (Full Thesis) student on 'Readability of textbook' was a source of inspiration to all of us. After listening from her, I thought of changing my topic and this created a lot of uncertainty to me. At home I became stuck in as far as framing my topic is concerned.

17/02/2010

I am quite happy today because my supervisor and my colleagues have assisted in formulating my topic as well as going about gathering data. We also visited the library to look for more reading material this was another step forward of my research. This is the last day of our contact session so I have to collect as much information as possible regarding my research so that I can work successfully at home.

19/02/2011

This is my first day at work after two weeks leave. It is hectic but I am glad because I will be visiting schools and I am intending to start collecting on the performance of grade 9 learners' performance on November/December 2011 Common Tests. This I did successfully.

So far I have visited 4 schools, I think this is enough. I asked the schools to make copies at least 5 scripts from each school.

I was hoping to work at the office after hours but I found out that that is impossible because we are busy visiting schools with the Provincial Officials. It is a norm of DoBE to visit schools in January and July. I have as such stopped dealing with my project altogether.

We are attending research course at RU for the whole week. Remember, I am still not sure of my research topic and today is the 8th of August 2010, it's my birthday and I have a new research topic, the third on so far.

We have started attending the workshop and the presenters are inspiring. Every time they present you find out that research has got its ups and down and everyone experiences that. I discovered that a lot crops up during the course of the investigation which might derail you one way or the other, so one must not lose focus but should stick to the research question/s. While we were visiting the library today, something strike my mind that when we were busy with our visits in the District, we always come to schools where teachers are faced with multigrade teaching. Remember that no one was trained to deal with such situations. I then thought of researching on 'Teaching science in a multigrade classroom' but Gerry, my colleague discouraged me.

It's the third day of the workshop and I think I'm looking the world with new eyes now. I'm a new person with new perception. I have noticed that RU does things in a unique way. For example, students doing B.Ed (Hons) degree are prepared for Masters Degree, so when they get to the Masters Degree they don't have any problem.

I'm now beginning to have a grip and direction such that my research question is becoming clearer day by day. I'm proud to say that most of the concepts have been clarified to me. I now talk the language of the academics. Attending the workshop was very fruitful because I gained a lot from it.

It's been a while now since the workshop and I'm worried because I have not yet submitted my proposal to Professor Baxter and McKenna as others have done. The thing is I'm now not sure about my research project once more in fact the challenge is framing it such that it makes sense. I have written finished writing my proposal but I still feel that something is missing. It's not as juicy as I wanted it to be it lacks something and t have failed to figure out what is it that is missing. Be that as it may I will hand it in to Dr Ngcoza before the end of the week so that he can submit it to the Professors.

I received feedback of my proposal and have got 50%, there is a lot that needs to be improved. I'm glad because very soon I'll meet my group then we will discuss our research proposals. I am a bit discouraged because I have to reframe my research topic once more. With the assistance of my supervisor and the group I managed to ultimately win and do touch ups here and there then it will be submitted to the committee for approval.

I have just received news from Dr Ngcoza that my proposal has been approved so I must proceed with my half thesis. I think I'm forced and bound to have a laptop so that I can be able to work on my thesis wherever and whenever I got opportunity to do so. I managed to buy a laptop and now I'm in a position to start working hard. There are a lot of disruptions. Firstly, I am staying with my grandson, her mother is at school. Although there is a child minder I am obliged to relieve her and take care of the child after work. So I have to wait until he is asleep before working on my thesis. Sometimes nannies stay for a few months and I will be without a nanny for a month or so.

Fortunately the nanny I employed as from August when I came from the hospital stays until the end of the year. This is a relief to me and I have started working seriously since her arrival. I have to have late nights and early mornings to catch up with my work.

Data gathering is also a challenge. When I am free, the participants are busy and vice versa. But at long last I managed to find a gap and carry on with my observations. This was a very interesting moment to all of us. I received warm welcome in both schools and everything was successful.

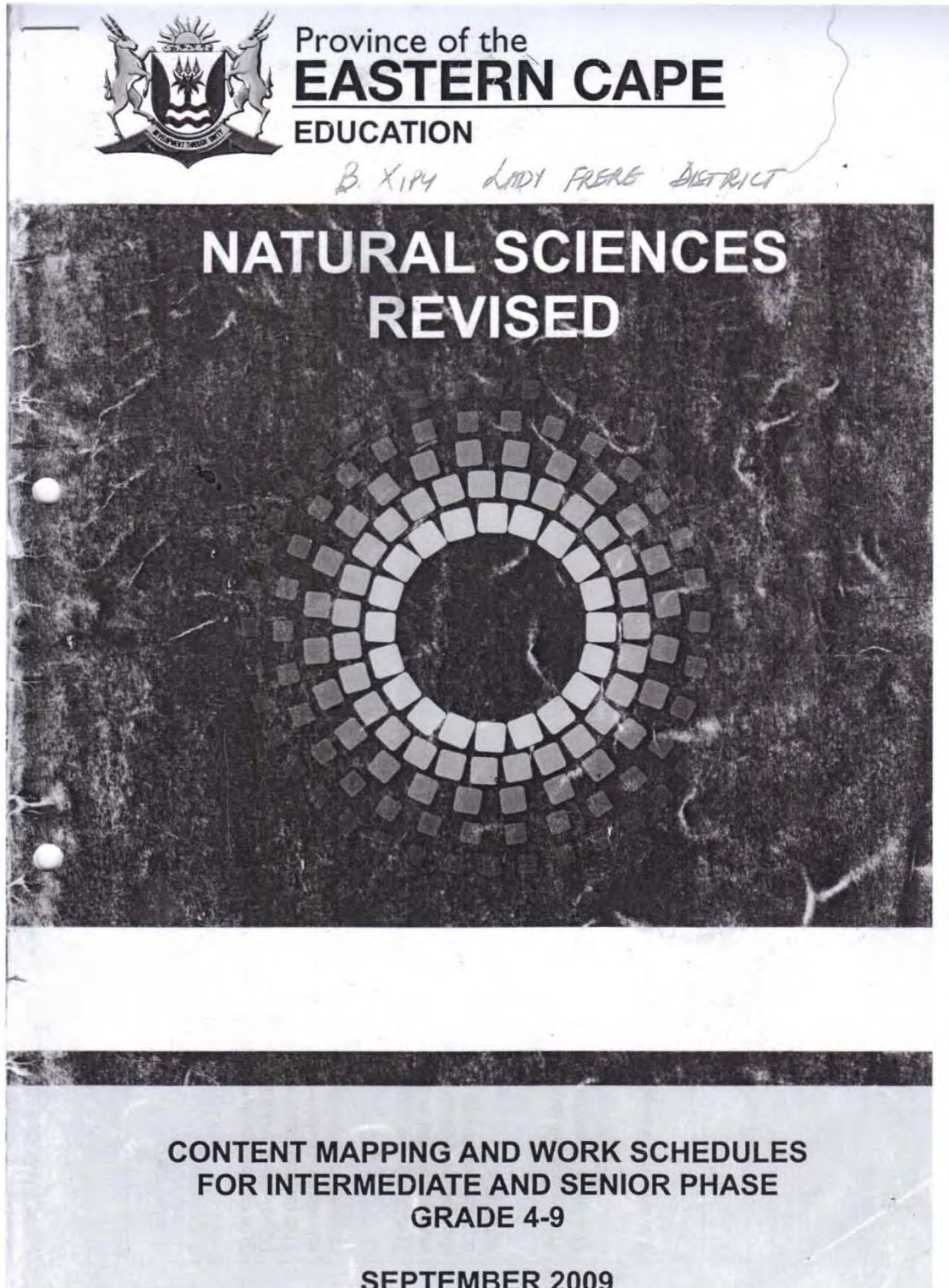
I have managed to submit 5 chapters. Wow writing up is challenging especially to people like us who are not speakers of the language (English). Language is the only problem here. But with the assistance of my supervisor I am coping.

My annual leave starts on the 27th of December 2011 and I'm prepared to work hard during my vacation. I have a problem with my email address and as such it became difficult to get feedback from my supervisor. It's also a problem to send the work I've done so far.

I do not have Christmas or New Year because I have to do final touches before the schools open because I won't have time to tuck my work if I don't finish now.

APPENDIX 6

(a)



INTRODUCTION

This revised content mapping and work schedule document is developed in alignment with the content mapping done by National Department of education.

This natural sciences guideline document was developed by the Eastern Cape Department of Education in collaboration with the district curriculum personnel, to give guidance to teachers in the preparation of lessons for teaching and learning in all schools. The process was initiated in response to teachers' requests for more clarity on the core knowledge and content statements in the NCS document.

This document provides lists of content for Grades 4 to 9. It also provides exemplars to show how content could be selected and spread across the year in a Work Schedule for each Grade. These Work Schedules serve to standardize the planning of teaching and learning in the Natural Sciences across the Province. Formal assessment tasks to be given to learners are also explained in full. Teachers are encouraged to use the content of this document to inform their selection of Learning and Teaching Support Material (LTSM) for their schools.

This document must be read and used in conjunction with the Natural Sciences Curriculum Statement, the National assessment Guideline Document and the Provincial Assessment Document.

We also invite suggestions for further improvement of this document.

Introduction to the content map of Natural Sciences Grade 4 to 9 and articulation with FET

The purpose of the Natural Sciences Content Map

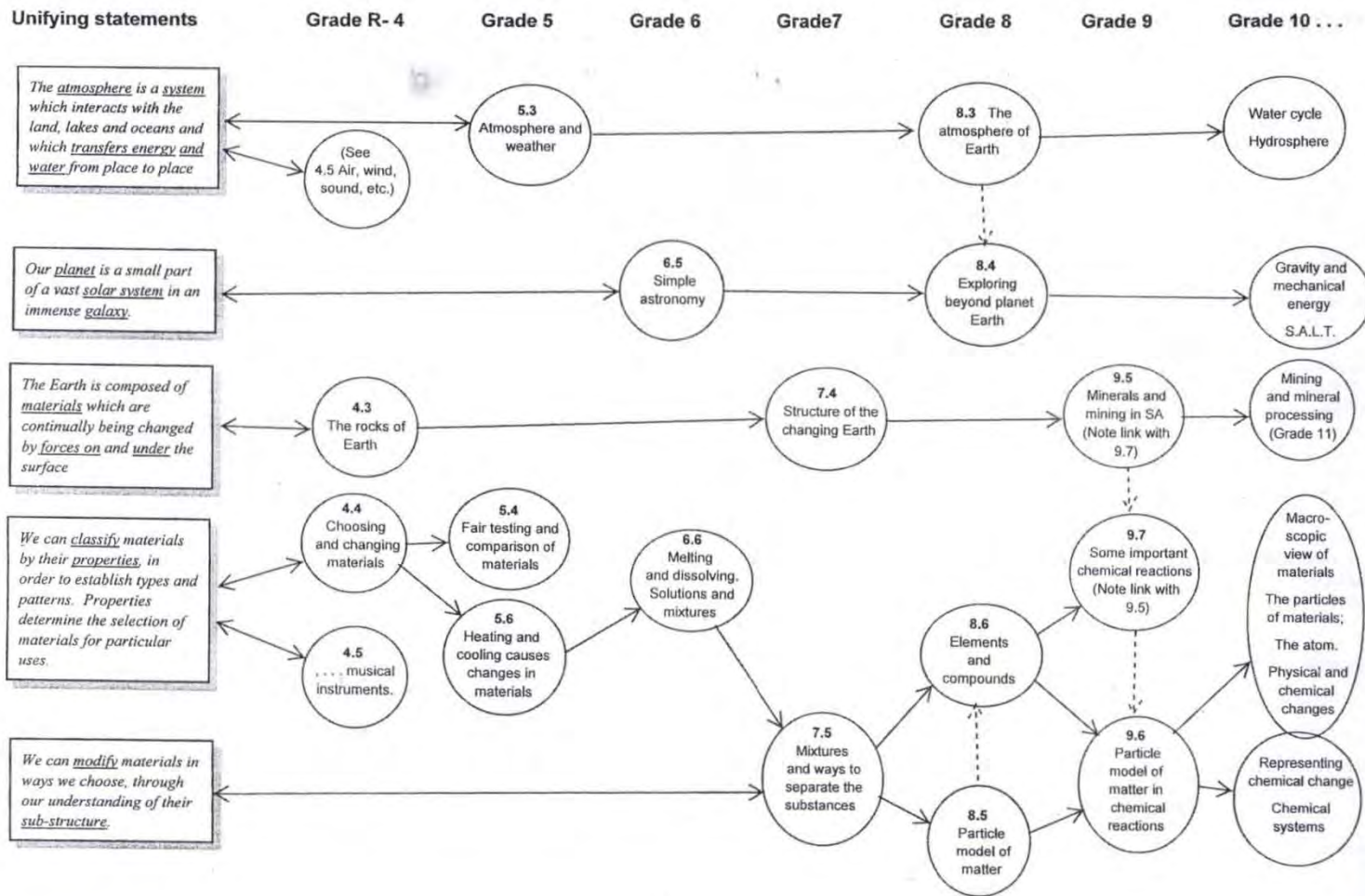
First of all, the Content Map does not represent new policy but is a clarification of the core knowledge statements in the NCS for Natural Sciences Grade R - 9 (Schools). It clarifies the content that learners should deal with at each Grade, arranged with conceptual progression in mind, so that by the end of Grade 9 they will have a good foundation of knowledge for taking Life Science, Agricultural Science or Physical Science in Grades 10 to 12. If the content is taught well, they will, hopefully, *choose* to take these subjects.

The implied choices for users of the document

This coverage of the NCS core knowledge is a strong recommendation by the National Department of Education, and comes with reasons and motivation. The "30% local option" remains in force. Learners must have a curriculum that is relevant to the situation of their school, and so local design of learning programmes is still needed. This document does not prescribe how the content should be covered in lessons or in textbooks. Different approaches are possible. The Assessment Standards for Natural Sciences must continue to be the drivers of lessons and activities. The topics have been given numbers and names for ease of reference only and these are not meant to prescribe the numbers or names of sections of learning programmes or textbooks. Content can still be grouped in other ways, using other themes, such as "transport" or "farming", provided that the concepts given in this Map are meaningfully learned. The numbers of the topics in a Grade (e.g. 8.1, 8.2, 8.3, etc) do not prescribe an order of teaching them during that year.

How to read the graphical map

Find the graphical map - with bubbles and arrows - on the next page. The boxes on the left hand side of the pages contain the **unifying statements** in the NCS core knowledge section, and these statements give the map its structure. The underlined words in those statements represent foundational concepts which learners must build up over the six years from Grade 4 to Grade 9. You see that the arrows from the unifying statements point both forwards and backwards. These unifying statements are compressed, powerful summaries of what we know and research in science. These statements develop in learners' minds as we provide them with multiple opportunities, year by year, to see what the concepts mean. The arrows that run from left to right mean, "learners need concepts in the previous topic to understand this new topic."



<p>Matter and materials 4.4 Choosing and changing materials</p> <ul style="list-style-type: none"> • Materials as substances we choose for particular uses • Properties of materials that learners can see, feel, hear, etc. ("Properties" as adjectives that describe materials) • Combining materials to get a new material that has new, different properties • Differences between solids, liquids and gases. <p>Note: Technology Grade 4 - <i>Processing and materials</i> - can complement this section.</p>	<p>Matter and materials 5.4 Fair testing and comparison of materials</p> <ul style="list-style-type: none"> • Matter is any kind of solid, liquid or gas. A material is any kind of matter that we choose to use for a particular purpose. • Properties of materials may be colour, smell, hardness, toughness, flexibility, strength in tension, • To compare materials on one of these properties, we have to test them in the same way. This is known as fair testing. 	<p>Matter and materials 6.6 Melting and dissolving, solutions and mixtures</p> <ul style="list-style-type: none"> • Melting contrasted with dissolving. • Melting and dissolving as examples of temporary changes. • A solution is an even mixture. Solvent, solute and solution. Water is one solvent but not the only solvent. • Soluble and insoluble substances. • Saturated solutions. • Factors of temperature and grain size in the rate of dissolving. • Conservation of matter means that when we can no longer see a solute, it still exists but as particles of solute among particles of the solvent. <p>(Note: This topic must be integrated with the Processing project in Technology at Grade6.)</p>	<p>Matter and materials 7.5 Mixtures and ways to separate the substances in mixtures</p> <ul style="list-style-type: none"> • Mixture as a substance made up of different substances that have different properties • The substances can be separated by physical methods. • Identifying physical properties of the substances in a mixture, to plan separations of mixtures, using various physical methods • Separation methods applied in problems of recycling waste materials. <p>This topic should reinforce the Technology curriculum where it deals with processing materials to improve their quality. - acids, bases Magnetism - magnetic fields</p>	<p>Matter and materials 8.5 The particle model of matter</p> <ul style="list-style-type: none"> • Most matter is made of molecules, and molecules are made of atoms that stick together. • Molecules and atoms are called "particles", with a special science meaning. • Particles (atoms and molecules) are too small to see, attract or repel each other, they move all the time, move faster when given energy, and between them is totally empty space. • The model allows us to explain changes of state (phase changes), the differences between solids, liquids and gases, dissolving, diffusion, heating by conduction. • The concept of models in science. <p>8.6 Elements and compounds</p> <ul style="list-style-type: none"> • Pure substances. • Most pure substances are compounds. • Compounds can break down into elements. 	<p>Matter and materials 9.6 The particle model of matter in chemical reactions</p> <ul style="list-style-type: none"> • Review all particle model of matter concepts done in Grade8.. • Models of molecules of common compounds. • Model simple reactions using beads, etc. • Represent reactions of elements and compounds in models, pictures, words and balanced chemical equations. <p>9.7 Some important chemical reactions</p> <ul style="list-style-type: none"> • Review Grade 8 work on elements and compounds • Models and symbolic representations of chemical change, chemical equations. • Examples of acids and bases. Reactions of acids and bases. Neutralisation. Indicators • Chemical equations, balancing. Begin with modelling.
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				<p>Two methods to break down compounds are heating and electrolysis.</p> <ul style="list-style-type: none">• Elements are made of just one kind of atom, whereas each compound is made of two or more kinds of atoms bonded together in unchanging proportions.• Elements may react to form compounds• Chemical reactions, models or other representations of the reactions• Symbolic representations, chemical equations• Application of reactions to produce and collect the gases oxygen, hydrogen and carbon dioxide• Properties of CO₂, O₂, H₂, N₂, Cl₂; this knowledge helps us distinguish the gases• Uses and importance of gases CO₂, O₂ in health, industry, environment, etc.	<ul style="list-style-type: none">• Reactions of metals and non-metals with oxygen.• Exothermic and endo-thermic reactions• Reactions of acids with metals, metal oxides, metal carbonates.• Differences in the reactivity of metals, reactivity series• Rusting as a reaction of iron with oxygen in water. Prevention of rusting.• Example of the reactions in a process to extract a metal from its ore. For example, displacement of a less reactive metal by a more reactive metal. (Link to 9.5 Mining and minerals)
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<p>4</p>	<p>LO 1: SCIENTIFIC INVESTIGATIONS AS: Plans investigations: AS: Conducts investigations and collects data AS: Evaluates data and communicates findings: LO 2 CONSTRUCTING SCIENCE KNOWLEDGE AS: Recalls meaningful information: AS: Categorize information AS: Interpret information AS: Applies knowledge LO 3 Science Society and the Environment AS: Understands science as a human endeavour: AS: Understands sustainable use of the earth's resources</p>	<p>LANGUAGE LO2: Speaking LO3: Reading LO5: Thinking and reasoning AS: Collects and records information in different ways TECHNOLOGY LO 1: Technological processes and skills MATHEMATICS LO 5: Data handling LIFE ORIENTATION LO 1: Health Promotion</p>	<p>MATTER AND MATERIALS The particle model of matter in chemical reactions 10. Exothermic and endothermic reactions 11. Reactions of acids with metal oxides- formation of molecules and write equations 12. Reactions of acids with metal carbonates- formation of product molecules and write equations Reactions of acids with metals-reactions, products and equations</p>	<p>Science kit Metals Acids Alkalies Indicators</p>	<p>Make models of molecules that form in a reaction when given the elements which begin the reaction.</p> <p>Predicting and identifying products of reactions. E.g reactions of acids with metal hydroxides.</p> <p>Predicting and identifying products of reactions, using models or other representations of the reactions. Apply particle model concepts to electrolysis and conduction in solutions when doing decompositions or extraction of metals from a compound.</p> <p>Classify the oxides of metals and non-metals using an indicator.</p>
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(h)

LESSON PLAN
MATTER AND MATERIAL

LEARNING AREA : NATURAL SCIENCE

GRADE : 9

DURATION : 1 hour

TOPIC : CHEMICAL REACTION

<u>LEARNING OUTCOMES</u>	<u>ASSESSMENT STANDARDS</u>	<u>INTEGRATION</u>
LO ₁ SCIENTIFIC INVESTIGATION	Plans investigations Conducts investigations and collects data Evaluates data and Communicates findings	LANGUAGES LO ₃ 4, 5 MATHEMATICS LO5 LIFE ORIENTATION LO5
LO ₂ CONSTRUCTING SCIENCE KNOWLEDGE	Recalls meaningful information Categorise information Interprets information Applies knowledge	SOCIAL SCIENCES LO2
LO ₃ SCIENCE, SOCIETY AND THE ENVIRONMENT	Understands science as a human endeavour Understands sustainable use of the Earth's resource	TECHNOLOGY LO3

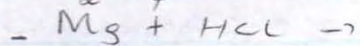
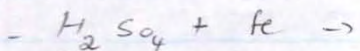
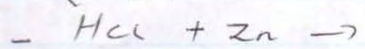
CONTENT : PREVIOUS KNOWLEDGE ABOUT ACIDS
: REACTION OF ACIDS WITH METALS

<u>LEARNING ACTIVITIES</u>	<u>TEACHING METHODS</u>	<u>RESOURCES</u>
REACTION OF AN ACID WITH METALS	Investigate the reaction of an acid with different metals Investigate how acid concentration affects the reaction with metals	Learner's book Teacher's guide Metals Acids

(i)

Activities

Equations without balancing



(i)

LESSON PLAN
MATTER AND MATERIAL

LEARNING AREA : NATURAL SCIENCE

GRADE 9

DURATION 45 Minutes

TOPIC : CHEMICAL REACTION

<u>LEARNING OUTCOMES</u>	<u>ASSESSMENT STANDARDS</u>	<u>INTEGRATION</u>
LO1 SCIENTIFIC INVESTIGATION	Plans investigation Conducts investigation and collects data Evaluate data and communication findings	LANGUAGES LO3, 4, 5 MATHS LOS
LO2 CONSTRUCTING SCIENCE KNOWLEDGE	Recalls meaningful information Interpretes information Applies knowledge	LIFE ORIENT LOS SOCIAL SCIENCES LO2
LO3 SCIENCE, SOCIETY AND THE ENVIRONMENT	Understand science as a human endeavor Understand sustainable use of the Earth's resource.	TECHNOLOGY LO3

CONTENT : REACTION OF METAL OXIDES

<u>LEARNING ACTIVITIES</u>	<u>TEACHING METHODS</u>	<u>RESOURCES</u>
REACTION OF ACIDS WITH METAL OXIDES	Investigate reaction of acid with metal oxides How acid concentration affects the reaction with	SCIENCE KIT

The oxygen in the copper oxide
broke away from the copper.
The hydrochloric acid molecules broke
down into hydrogen and chlorine.
Then, one oxygen and two hydrogen atoms
joined together

LESSON PLAN

LEARNING AREA NATURAL SCIENCES

Grade 9

Date : _____

Duration: 1 week (4 periods) Content in Context : REACTIONS OF ACIDS WITH CARBONATES, METALS & METAL OXIDES

LO's and AS's	LEARNING ACTIVITIES	ASSESSMENT: AND TOOLS	PROVISIONS FOR LEARNERS WITH BARRIERS
<p><u>LO1 : SCIENTIFIC INVESTIGATIONS</u></p> <p>AS: Plans investigations AS: Conducts investigation AS: Evaluates data and communicates findings.</p> <p><u>LO2 : CONSTRUCTING SCIENCE KNOWLEDGE</u></p> <p>AS: Recalls meaningful information AS: Interprets information.</p> <p><u>LO3 SCIENCE, SOCIETY AND THE ENVIRONMENT</u></p> <p>AS Understands Science and Technology.</p>	<p><u>Activity 1:</u> The teacher gives learners a revision exercise on household acids and bases and lab acids and bases. They also revise their properties and pH values.</p> <p><u>Activity 2:</u> An experiment of a reaction of an acid and metals is done in class. Apparatus is set and learners follow instructions on their worksheets. A metal to be used can either be zinc or magnesium ribbons. The teacher emphasizes on writing of equation reactions in words and in the form of an equation. Balancing of equation is done.</p> <p><u>Activity 3</u> An experiment of a reaction of an acid and carbonates is done in class. Examples of compounds that fall in this group are dealt with. Carbonates we deal with, in real life are mentioned.</p>	<p>Forms, Methods</p> <p>Questioning - during revision</p> <ul style="list-style-type: none"> o Observation o Recording o Investigating 	<p>If your class is overcrowded or has immovable furniture, learners with vision problems should be seated in the front group.</p>

Activity 4 : An experiment of a reaction of an acid with a metal oxide is done in class. They (learners) use copper oxide.

Resources:- Worksheets, Stationery, Science Kit, Old kettles, Chalk, Lime water, Textbooks

Teacher Reflection

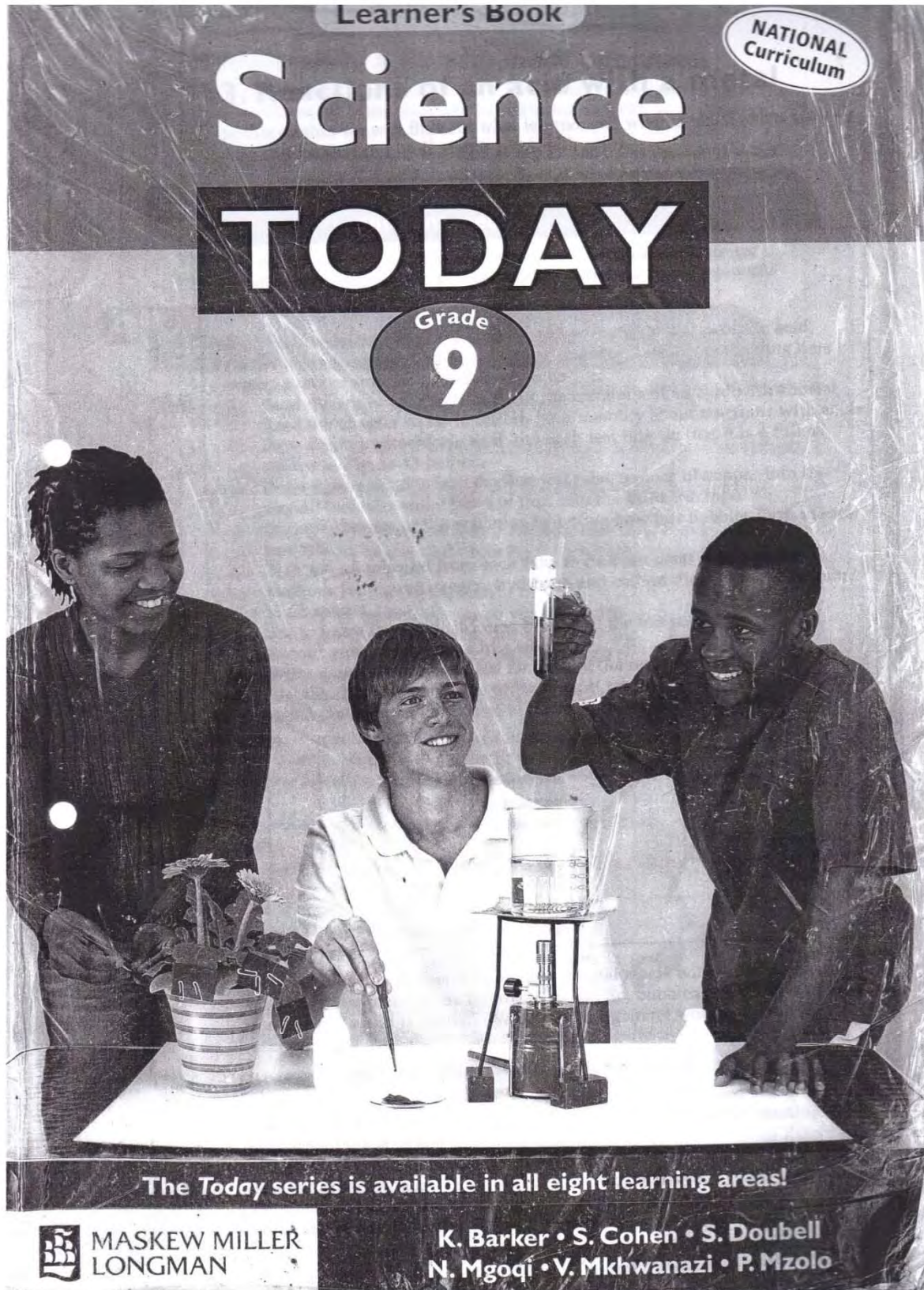
How the lesson could have been presented differently?

The teacher could use one metal from the metals chosen in the textbook so that learners get same result. But it also helps to use different metals to give a wide range of results eg. they observed that ^gmagnesium ribbon reacts faster than zinc.

Did the practical activity go well?

It is always best to do practical activities because everybody writes what he/she observes. The reaction of acid and metal went well.

(1)



2.2 Reactions of acids with metal oxides

A

Activity 6 Investigate the reaction of an acid with a metal oxide

LO1 AS: Conducts investigations and collects data, AS: Evaluates data and communicates findings; LO2 AS: Interprets information, AS: Applies knowledge

You will need: black copper oxide, dilute hydrochloric acid, a beaker, an evaporating basin, a tripod and gauze, a Bunsen burner or spirit burner, safety goggles, filter paper, a filter funnel, glass stirring rod, water

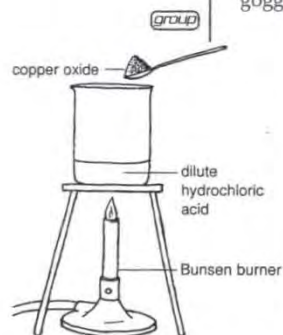


Figure 7: Adding copper oxide to dilute hydrochloric acid



Figure 8: Filtering the solution

1. Look at Figures 7 and 8 carefully.
2. Pour 50 ml of water into a beaker and carefully add 5 ml of hydrochloric acid (HCl), as in Figure 7.
3. Gently heat the contents of the beaker. Make sure the solution does not boil.
4. When the solution is warm, slowly add two spatulas of copper oxide (CuO) and stir with a glass rod.
5. What do you see happening?
6. Add more copper oxide until you see that the reaction has stopped. The reaction stops when all of the acid has reacted.
7. Filter the solution and collect it in an evaporating dish (Figure 8). This removes the excess copper oxide.
8. Gently heat the filtered solution in the evaporating dish until crystals start to form. Turn off the Bunsen burner.
9. Leave the solution to cool. What do you notice happening in the evaporating basin? Cover the solution with a piece of filter paper.
10. What salt do you think was formed? Write a word equation for the reaction.
11. What can you conclude about reactions of acids with metal oxides from this investigation?

Updated and aligned to the NCS Assessment Guidelines.



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Spot On

Natural Sciences

Learners' Book

Grade 9

2.4 Reactions of acids with metal carbonates

A **metal carbonate** is a compound made of a metal, carbon and oxygen. The formula for all metal carbonates will have a metal and CO_3 in it. Calcium carbonate (also known as chalk) is an example of a metal carbonate. Its chemical formula is CaCO_3 . If you look at the formula you can see that the metal part is calcium (Ca) and the carbonate part of the compound is the CO_3 (carbon and oxygen).

Limestone, chalk and marble are all forms of calcium carbonate. Calcium carbonate is found in the shells of sea animals that died millions of years ago. There are different forms of calcium carbonate because the shells of the sea animals have been heated and squashed underground to different extents.

A Activity 10 Investigate the reaction between a metal carbonate and an acid

LO1 AS: Conducts investigations and collects data, AS: Evaluates data and communicates findings; LO2 AS: Interprets information, AS: Recalls meaningful information

You will need: pieces of chalk, a test tube, dilute hydrochloric acid or vinegar, safety goggles

GROUP

1. Read the above information about reactions between acids and metal carbonates.
2. Pour dilute hydrochloric acid into a test tube until it is about $\frac{1}{3}$ full.
3. Carefully place a piece of chalk into the hydrochloric acid.
4. Record your observations.
5. What gas do you think is produced?
6. Think of a way to capture the gas so you can test it to see which gas is produced. Use the tests for hydrogen, carbon dioxide and oxygen, which you learnt in Chapter 4.
7. Draw a diagram to show the apparatus you would set up to capture the gas.
8. What else do you think is produced in the reaction?
9. Use the particle pictures in Figure 12 below to write a balanced equation for the reaction.

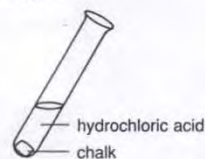


Figure 11: Reacting an acid and a metal carbonate

The reaction can be shown as a general word equation:

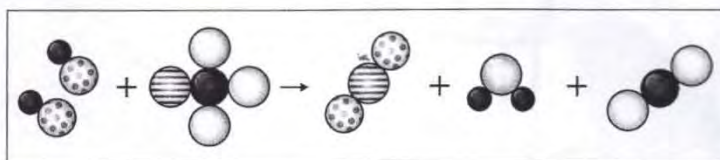


Figure 12: Particle picture of the reaction between hydrochloric acid and calcium carbonate



Activity 9.2 Investigate the reaction of acids with metals

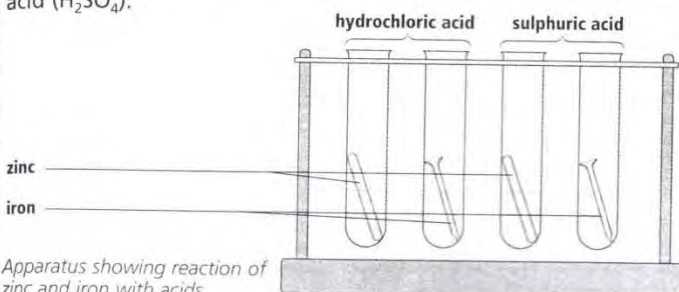
NS LO 1 AS 2, AS 3

FAL LO 5 AS 2

MATHS LO 5 AS 2

You will need:

four test tubes; a test tube rack; freshly cleaned zinc or granulated zinc; a few iron nails; dilute hydrochloric acid (HCl); dilute sulphuric acid (H_2SO_4).



Apparatus showing reaction of zinc and iron with acids

What you need to do:

1. Mark your test-tubes A, B, C and D.
2. Fill test tubes A and B with about 20 ml of HCl solution.
3. Fill test tubes C and D with about 20 ml of H_2SO_4 solution.
4. Place the zinc in test tubes A and C.
5. Place the iron nails in test tubes B and D.
6. Write down the changes that you observe in each test tube.
7. Test for the gas released by holding a burning splinter at the mouth of the test tube. A pop sound is heard if hydrogen gas is present.
8. Write a conclusion for your experiment.

A salt is formed when the hydrogen atoms in an acid are replaced with metal atoms.

So: acid + metal \rightarrow salt + hydrogen

Activity 9.3 Investigate the reaction of acids with metal oxides

NS LO 1 AS 2, AS 3

MATHS LO 5 AS 2

FAL LO 5 AS 3

You will need:

small quantities of metal oxides like copper oxide and magnesium oxide; test tubes; test tube racks; dilute hydrochloric acid (HCl); dilute sulphuric acid (H_2SO_4).

1. Half fill a test tube with the dilute acid. Add a very small quantity of each metal oxide to the dilute acid.
2. Draw a table to show the colour changes that occur in each test tube.

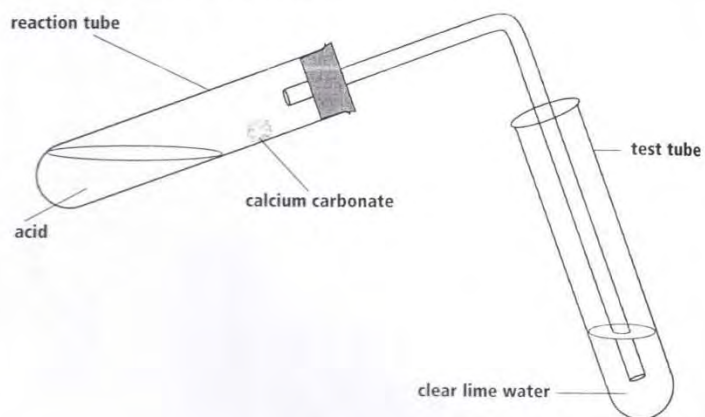
The blue solution that formed when copper (II) oxide reacted with sulphuric acid is called copper sulphate. Magnesium oxide formed a colourless solution of magnesium sulphate. Copper sulphate and magnesium sulphate are both salts.

So: metal oxide + acid \rightarrow salt + water

Activity 9.4 Investigate the reactions of acid with a carbonate

NS LO 1 AS 2, AS 3
MATHS LO 5 AS 2

Your teacher will demonstrate this experiment to you using the apparatus shown in the diagram.



effervescence:
when a
substance gives
off bubbles.

1. What happens inside the reaction tube? This bubbling reaction is called **effervescence**.
2. What happens to the lime water?
3. What does this show about the gas that is produced?

So: acid + carbonate \rightarrow salt + carbon dioxide + water

(n)

10W29 - GROUP 1

PRACTICAL ACTIVITY WORKSHEET

REACTION OF ACIDS WITH METALS

Using syringe, pour a small amount of Hydrochloric acid in a test tube. Put a metal into the acid (magnesium or Zinc)

Write the reactants of your reaction.

The reaction of magnesium the hydrolic acid
it reacts by boiling and the test tube is
get hot

Record what you see when you put the metal in the acid

We see bubbles and the test tube became
hot

Write this reaction in words and in an equation form

Magnesium + Hydrochloric Acid \rightarrow Magnesium chloride + Hydrogen
 $Mg + HCl \rightarrow MgCl_2 + H_2$

Balance it

$2HCl + Mg \rightarrow MgCl_2 + H_2$

How do you test the gas that has been formed?

We had a pop sound

GROUP 2

PRACTICAL ACTIVITY WORKSHEET

REACTION OF ACIDS WITH METALS

Using syringe, pour a small amount of Hydrochloric acid in a test tube. Put a metal into the acid (magnesium or Zinc)

Write the reactants of your reaction.

Zinc Granules and Hydrochloric acid

Record what you see when you put the metal in the acid

In the test tube there were bubbles and the tube became hot.

Write this reaction in words and in an equation form

Zinc + Hydrochloric acid = Zinc Chloride + Hydrogen
 $Zn + HCl = ZnCl_2 + H_2$

Balance it

$2HCl + Zn \rightarrow ZnCl_2 + H_2$

How do you test the gas that has been formed?

There were a popping sound and smell

Group 3

PRACTICAL ACTIVITY WORKSHEET

REACTION OF ACIDS WITH METALS

Using syringe, pour a small amount of Hydrochloric acid in a test tube. Put a metal into the acid (magnesium or Zinc)

Write the reactants of your reaction.

The reactants of a reaction we have magnesium to the hydrochloric
or Acids

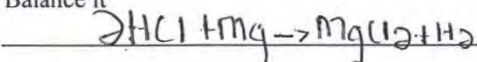
Record what you see when you put the metal in the acid

After a minute the metal dissolve to the hydrochloric Acid

Write this reaction in words and in an equation form

Magnesium and Hydrochloric Acid \rightarrow Magnesium chloride and Hydrogen
 $Mg + HCl \rightarrow MgCl_2 + H_2$

Balance it



How do you test the gas that has been formed?

During the open tube we hear the small pop sound.

GROUP 1

PRACTICAL ACTIVITY WORKSHEET

REACTION OF ACIDS WITH CARBONATES

- > What are components of a carbonate?

Oxygen & Carbonate

- > Its chemical formula is CaCO_3

- > Pour hydrochloric acid into a test tube and put a granule of calcium carbonate or chalk into a test tube. Collect the gas produced in another test tube. Write the reactants of this reaction as words.

Words	formulae
Oxygen	O_2
Carbon	CaCO_3

- > Record your observations

Bubble became faster and the gas that flow to another test tube with a liquid ~~test~~

- > What gas do you think is produced?

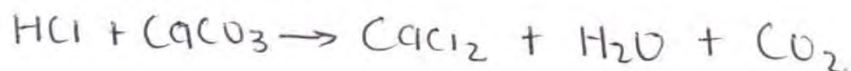
It produce bubbles

- > How will you test it to make sure that it is the gas you think it is?

The gas became than before

- > Write this equation in words and in the form of an equation.

Hydrochloric acid + Calcium carbonate \rightarrow Calcium chloride + water + carbon dioxide



GROUP 2

PRACTICAL ACTIVITY WORKSHEET

REACTION OF ACIDS WITH CARBONATES

- What are components of a carbonate?

Carbon + Oxygen

- Its chemical formula is CO₃

- Pour hydrochloric acid into a test tube and put a granule of calcium carbonate or chalk into a test tube. Collect the gas produced in another test tube. Write the reactants of this reaction as words.

Words	formulae
Hydrochloric acid	HCl
Calcium Carbonate	CaCO ₃

- Record your observations

The are Small Bubbles and there is a mist.

- What gas do you think is produced?

Carbon dioxide

- How will you test it to make sure that it is the gas you think it is?

lime water is turned milky

- Write this equation in words and in the form of an equation.

Hydrochloric acid + Calcium Carbonate → Salt + Water + Carbon dioxide

GROUP 3

PRACTICAL ACTIVITY WORKSHEET

REACTION OF ACIDS WITH CARBONATES

- What are components of a carbonate?

Carbon and Oxygen

- Its chemical formula is CO_3

- Pour hydrochloric acid into a test tube and put a granule of calcium carbonate or chalk into a test tube. Collect the gas produced in another test tube. Write the reactants of this reaction as words.

Words	formulae
hydrochloric acid	HCl
Calcium Carbonate	CaCO_3

- Record your observations

There is no change

- What gas do you think is produced?

Carbon dioxide

- How will you test it to make sure that it is the gas you think it is?

lime water turned milky

- Write this equation in words and in the form of an equation.

hydrochloric acid + Calcium Carbonate

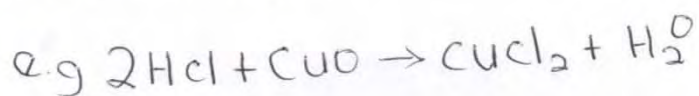
(o)

REACTION OF ACID WITH A METAL OXIDE

The colour of copper oxide was light green in colour but after heating it changes to blue

Copper oxide is in a solid form but dissolves in water to be in a liquid form

When an acid reacts with an oxide it forms salt and water



2

REACTION OF ACID WITH METAL OXIDE

After the solution is heated the oxygen in the copper oxide broke away from the copper. The hydrochloric acid molecules broke down into hydrogen and chlorine.

Then oxygen and hydrogen atoms joined together to form water.

The copper and chlorine atoms joined together to form copper chloride.

Copper chloride is a salt and it dissolves in water. When you filtrate this solution salt is left in the evaporating dish.

Therefore Acid + metal oxide = salt + water.

3 REACTION OF ACIDS WITH METAL

TEMPERATURE INCREASE CRYSTALLINE FORM

HCl and H₂SO₄ are blue solution
The molecules of HCl disappear and hydrogen and chlorine is formed and
and the water is formed by one oxygen and two hydrogen.
when the water is heated the salt left behind ie Copperchloride

Conclusion: Acids react with oxides to form salt and water (salt)
e.g $2HCl + CuO \rightarrow CuCl_2 + \text{water}^{H_2O}$

Acids - react with oxides to form salt water

e.g $2HCl + CuO \rightarrow \overset{\text{(salt)}}{CuCl_2} + \overset{\text{(H}_2\text{O)}}{\text{water}}$

LEARNER'S REFLECTION

Group 1

Science is easier when we do it practical because by the time the teacher told me about these reaction I did not understand exactly but after this investigation I gained a lot.

Understanding level differs

LEARNERS Reflection

3

During the investigation of Acid with metal oxide

I notice that shortage of Science kit makes the lesson unclear because the colour we found during investigation was total differ when we compare as the colour we knew because we were using stove instead of burnsen burner

2

LEARNERS REFLECTION

By the time of this investigation

I learnt a lot because I was confusing

I think the gas given off when we react acid with metal is carbon dioxide but now

I notice that it is a hydrogen. Carbon

dioxide is given off when acid react with carbonate, acid react with metal

hydrogen is given off and when acid

react with oxide water is given off.

TEACHERS REFLECTIONS

I was presenting my lesson on reactions of Acid with metals, metal oxide and Carbonate. My presentation did not went well because in this school we use theory teaching because of the science kit shortage. All what I told during the classroom situation was not the same as they did practical because the kit we used was the man made it dont give us exactly what we need so the learners found difficulties to observe these investigation. But at the same time it gives me a better confidence because the reflection after my presentation gives me a better strength.

(q)

NATURAL SCIENCES: GRADE 9				
TERM 1				
AREA 1: MATTER AND MATERIALS				
TIME	TOPIC	CONTENT	PRACTICAL WORK	RESOURCES
8 weeks (24hours)	Chemical reactions	<ul style="list-style-type: none">• <i>Missing bullet - Prior Knowledge</i>• Pure substances, elements and compounds. Classify substances.• Names of elements, symbols.• Names of compounds, using names of elements from which they derive; common names of compounds, for instance water, salt.• Properties of metals.• Properties of non-metals.• Introduction to the periodic table: Mendeleev, patterns in the periodic table.• Chemical reactions (word equations):<ul style="list-style-type: none">- useful reactions, for instance metal from metal oxides, silver nitrate in photography.- harmful reactions, for instance rusting.- acids and bases (pH measurement), for instance swimming pool chemistry.- anions and cations.• Balanced chemical equations (symbols).• Careers in chemistry (inorganic or organic), chemical engineering, manufacturing, etcetera.	<ul style="list-style-type: none">• Investigate the properties of metals:<ul style="list-style-type: none">▪ hot water and Vaseline or wax to test for conductivity.▪ 9-volt battery and wires to test for electrical conductivity.▪ hammer and pliers to test for malleability and ductility. Construct a table to show results. Report on conclusions. <ul style="list-style-type: none">• Investigate the properties of some nonmetals. Construct a table to show results.• Investigate reactions between weak acids and bases.	<ul style="list-style-type: none">Textbook.Periodic table.Assortment of metals: copper, zinc, aluminium, lead, tin etcetera.9-volt battery.Vaseline or wax.Pliers.Hammer.Heat source.Thermometer.Indicator strips.• Carbon rod, sulphur, graphite,

(r)

Properties and Uses of Materials	Structure, Reactions and Changes of Materials
<i>Senior Phase</i>	
<ul style="list-style-type: none">❖ Substances in different states ("phases") have distinct properties such as crystalline structures, or compressibility/incompressibility, or tendency to diffuse.❖ Dark-coloured surfaces get hotter than light-coloured surfaces when exposed to radiating sources of energy like the sun. Dark-coloured objects radiate their energy as heat more readily than shiny light-coloured objects. <i>(Links with Energy and Change)</i>❖ Some materials are magnetised by electric currents or magnets. Some materials can be electrically charged by rubbing them with a different material. <i>(Links with Energy and Change)</i>❖ Some conductors and circuit components reduce the current in an electric circuit to a significant extent and are called resistors. Resistors can be selected or designed to control currents.❖ A pure substance cannot be separated into different substances, while a mixture can be separated, usually by physical means. Differences in properties can be used to separate mixtures of different substances (by methods such as filtration, distillation, evaporation, chromatography or magnetism). <i>(Links with Matter and Materials)</i>❖ Specific gases may be separated from the air or produced in reactions, and have many uses in industry and other sectors of the economy. Oxygen, hydrogen and carbon dioxide have characteristic properties and reactions by which we can identify them.❖ Extracting useful materials from raw materials depends on chemical reactions and methods of separation.❖ Raw materials, from which processed materials are made, must be mined, grown or imported from other countries. Raw materials that are mined are non-renewable and mining has environmental costs. Growing raw materials involves choices about the use of arable land and water catchment areas.	<ul style="list-style-type: none">❖ A particle model of matter can explain physical changes of substances such as melting, evaporation, condensation, solidification, diffusion and heating by conduction.❖ Many household substances are acidic or basic. Indicators are substances that react with acids and soluble bases to produce products that have distinctive colours. Acids and bases neutralise one another to form salts. Acids have characteristic reactions with metals, metal oxides, hydroxides and carbonates.❖ Many chemical reactions need some energy to get started; many chemical reactions give off energy as they happen.❖ Elements are made of just one kind of atom, whereas compounds are made of two or more kinds of atoms in fixed proportions. Elements may react to form compounds, and compounds may be decomposed into their elements. Energy input is needed to break a compound into its elements, whereas energy is given out when elements react to form a compound.