

**An investigation into how grade 9 Physical Science learners make meaning
of the topic on acids and bases through exploring their prior everyday
knowledge and experiences: A case study**

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By

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DECLARATION

I, **Linus Kambeyo (09K6352)** 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 to any university for a degree.

Signature.....

Date.....

ABSTRACT

This study was conducted at the school where I teach which is a semi-rural secondary school (Grade 8-12) situated in Omuthiya Town in Oshikoto region, Namibia. The new curriculum that has been implemented in Namibia, has posed challenges in how best to put the curriculum into practice at this school. It was this challenge that triggered my interest in doing a research study with the aim of improving my practice. Essentially, the study sought to gain insight into whether integrating learners' prior everyday knowledge and experiences of acids and bases in conjunction with practical activities using easily accessible materials enabled or constrained meaning-making of this topic.

This study is located within an interpretive paradigm. Within this paradigm, a qualitative case study approach was adopted with my Grade 9 class. Data were gathered using document analysis, videotaped lessons and observations by a critical friend, stimulated recall discussions while watching the videotaped lessons as well as focus group interviews with the learners. An inductive analysis to discover patterns and themes was applied during the data analysis process. The themes were further turned into analytical statements. Data sets were also analysed in relation to the research questions posed by this study.

The validation process was achieved by using a variety of data gathering techniques. I watched the videotaped lessons with a teacher who observed the lessons and transcripts of the interviews and a summary of discussions were given back to the respondents to verify their responses and check for any misinterpretations, a process known as member checking. I also translated what the learners said in Oshiwambo, their home language, into English.

The findings from the study revealed that the use of learners' prior everyday knowledge and experiences of acids and bases facilitated meaningful learning during teaching and learning. Furthermore, linking learning to learners' everyday experiences enabled them to learn scientific concepts in a relaxed and non-threatening environment. However, linking learners' prior knowledge and experiences to conventional science (textbook science) proved to be a challenge. My recommendations are that teachers need support in their endeavors to incorporate learners' real life experiences into their teaching and learning repertoires. Another aspect of my study that deserves further research is the role that language plays in implementing the curriculum.

DEDICATION

This thesis is dedicated to my mom, Anna Petrus, dad, Rafael Johannes, my late brothers and my lovely five sisters for their love, warmth and for supporting me and each other through the good and bad times. You guys are a blessing to me!

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LIST OF ABBREVIATIONS AND ACRONYMS

OBE -	Outcomes based education
NIED -	National Institute of Education Development
POE -	Predict, Observe, Explain
PEEOE -	Predict, Explain, Explore, Observe and Explain
MBSEC -	Ministry of Basic Education Sport and Culture
MHETEC -	Ministry of Higher Education, Technology and Employment Creation
MEC -	Ministry of Education and Culture
LCE -	Learner-Centered Education
OH- -	Hydroxyl group (Hydroxide ions)
MoE -	Ministry of Education
ZPD -	Zone of Proximal Development
NSSCO/H -	Namibia Senior Secondary Certificate Ordinary level/Higher level
SRI -	Stimulated Recall Interview
MoI -	Medium of Instruction
EHDC -	Education Higher Degree Committee
LTSMs -	Learning and Teaching Support Materials

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CHAPTER ONE

RESEARCH CONTEXT

As constructivists we see learners as mentally active agents struggling to make sense of the world. And all we come to know is our own construction (Bettencourt, 1993, p. 39).

1.1 Introduction

With the dawn of democracy in 1990, Namibia was accepted into the global village of nations and entered a new era fraught with challenges. These included the limited knowledge and skills of the majority of its citizenry, which impeded its ability to engage with other nations in a competitive, technologically advanced and ever-changing political, economic, social and cultural environment (Ministry of Education, 1993, p.14).

In an attempt to address these challenges and enhance the knowledge and skills of society at the school level, the Namibian government began developing a new curriculum. The curriculum has subsequently undergone many reforms and changes, as reflected in the successive curricula 1993-1995, 1996-2000, 2000-2005, 2005-2007, and now curriculum 2010 to 2014. These many reforms have required new teaching methods and approaches towards teaching and learning.

Acquainting myself with these curriculum reforms and changes, and relating them to my everyday teaching and learning experiences, I decided to embark on a project to learn more about prior everyday knowledge, about its elicitation from learners and about the possibility of incorporating it into practical activities. This was done with a view to promoting learners' meaning making, conceptual development and understanding of chemistry, with a particular focus on acids and bases. I also wanted to find out if it was possible to use easily accessible materials to make science understandable to my learners. This encouraged me to engage in this research study.

This chapter introduces my study, which investigated the integration of learners' prior everyday knowledge and experience with practical activities on the subject of acids and bases, with a view to enhancing their meaning making, conceptual development and

understanding. In this chapter, I briefly outline the curriculum issues, problem statement, and significance of my study, identifying its research goal and questions and describing its organization.

1.2 Curriculum Issues

The traditional methods of science teaching and learning are today widely regarded as rigid, stereotyped and syllabus bound. Textbook knowledge has been, and to some extent still is, the focus of knowledge dissemination. The inculcation of scientific formulae and definitions, accompanied by lengthy explanation, is still believed to be the acceptable method of science teaching. It seems to me, however, that such an approach to science teaching does not necessarily promote conceptual development and understanding, and that one of its limitations is its failure to make connections between classroom instruction and learners' everyday life and experience.

Presently, South Africa is engaged in a curriculum transformation process similar to that in Namibia. There is Curriculum 2005 (C2005) which is underpinned by the outcomes-based education (OBE) philosophy (Curriculum 2005, 1997, p. 16; Review of the Committee on Curriculum 2005, 2000, p. 8). The new curriculum is gaining momentum and demands a shift from content-based education to skills-based education, with an emphasis on the four educational pillars of skills, knowledge, attitude and values (Curriculum 2005, 1997, p. 19; Review of the Committee on Curriculum 2005, 2000, p. 35). Furthermore, in this curriculum, as in the Namibian curriculum, learners' prior everyday knowledge is regarded as important (Wilkinson & Kuiper, 1999). However, it is not clear from the curriculum documents how learners' prior knowledge is supposed to be incorporated into teaching and learning.

Before Independence in 1990, teaching in Namibia was teacher-centred, just as it was in South Africa. Strict adherence to a fixed curriculum was highly valued and teaching and learning relied heavily on prescribed textbooks. Learners were viewed as 'empty vessels' and teachers generally behaved in a didactic manner, disseminating information to learners (Moll, 2002). According to Moll (2002, p. 7), this was exacerbated by the fact that assessment of learning occurred almost entirely through testing. This resulted in learners memorizing scientific concepts without understanding them. Consequently, many of them lost interest in learning science.

After Independence, however, the Namibian government changed its education system, moving away from teacher-centred approaches to learner-centred teaching and learning. It introduced a curriculum underpinned by the constructivist theory (as indicated in the epigraph above) which, notably for this study, emphasizes, among other things, that the integration of learners' prior everyday knowledge with practical work is crucial to facilitating meaningful learning (Ministry of Education, 1993, p. 80). That is, the emphasis now falls more upon conceptual development and understanding as well as the integration and application of knowledge to everyday life. Moll (2002) also emphasizes the need for educators to mediate and promote interactive lessons with their learners.

1.3 Problem statement

In the past, practical activities and teacher demonstrations were prescriptive, based on repetition of the verification of predetermined scientific principles through mere demonstration of the outcomes (Hodson & Hodson, 1998, p. 685). For example, learners might be shown that lime water will turn milky in the presence of carbon dioxide; but later, when asked how carbon dioxide turns lime water milky, they will not be able to explain their observation. All they know is that it turns milky in the presence of carbon dioxide. The mechanism of the operation has not been explained: that carbon dioxide reacts with the calcium hydroxide (lime water) to form a precipitate of calcium carbonate in water, which is whitish in colour.

On the other hand, more modern approaches to the use of practical activities in science teaching, such as those advocated by Hodson and Hodson (1998), involve incorporating what the learners already know: delving into the underlying mechanisms at work and making the activity more real by linking it to everyday experiences.

In reflecting on my own practice, I have come to realize that my teaching of science has been characterized by a focus on practical demonstrations. I have tended to pay little attention to my learners' prior knowledge and experience. But last year, 2011, I became interested in exploring the possibility of improving my science teaching by incorporating examples of learners' everyday knowledge into some of my science lessons.

In my view, if teachers are to succeed in this endeavour of bringing science and meaning in science to life, they need to try out different ideas on how to create meaning during the teaching and learning of science. It seems self-evident that learning will be enhanced when

learners see connections between what they are being taught and their own experiences. It is for these reasons that the Natural Sciences curriculum statement for grade 8-12 (NIED 1993 & Curriculum, 2010) emphasizes the need for teachers to integrate their lessons with the everyday knowledge of learners, since this strategy, if correctly followed, will facilitate the process of learning (Roschelle, 1995). It is recognized, however, that this is more easily said than done.

For instance, after the new curriculum was introduced in 1993, there were still many arguments about how to approach the teaching and learning of science in schools. This is because the 1993 curriculum involved the development of a range of process skills that could be used in everyday life (NIED, 1993), but tended to ignore the use of learners' everyday knowledge and experience. This led to the development of the new curriculum in 2010, which features a particular emphasis on the incorporation of learners' prior knowledge during the teaching and learning process.

I therefore decided to investigate the integration of learners' prior, everyday knowledge and experience with practical activities on acids and bases, with a view to enhance meaning making, conceptual development and understanding.

1.4 Significance of this study

This research study sought to enhance understanding of the potential of integrating learners' everyday knowledge and experience in the teaching and learning of acids and bases, with an emphasis on using everyday materials familiar to learners. The study might provide general insight into the role of practical activities in the science class, in helping to make the abstract more concrete and clear. The study might provide specific insights into the teaching of acids and bases and related scientific concepts and processes, and hence cast light on the potential of the use of everyday materials and activities to arouse learners' interest in science.

Furthermore, it is envisaged that this study will promote the use of a variety of teaching and learning support materials, with textbooks used for reference rather than as sole sources of knowledge.

1.5 Research goal and Questions

The study aimed to investigate the integration of learners' prior, everyday knowledge and experience with practical activities on acids and bases, with a view to enhance meaning making, conceptual development and understanding.

To achieve this goal I endeavoured to answer the following questions:

- What prior everyday knowledge and experiences related to acids and bases do grade 9 learners bring to the science classroom?
- Does elicitation and mobilization of learners' prior everyday knowledge and experiences regarding acids and bases enable or constrain learner engagement?
- Does learner engagement enable or constrain meaningful learning?
- Does integrating learners' prior knowledge and experience with practical activities enable or constrain meaning making, conceptual development and understanding of acids and bases?

1.6 Context of the study

Namibia is on the Atlantic coast of Southern Africa. It is divided into thirteen political and educational regions: Caprivi, Erongo, Hardap, Oshana, Otjozondjupa, Ohangwena, Omusati, Omaheke, Kunene, Kavango, Oshikoto, Karas and Khomas.

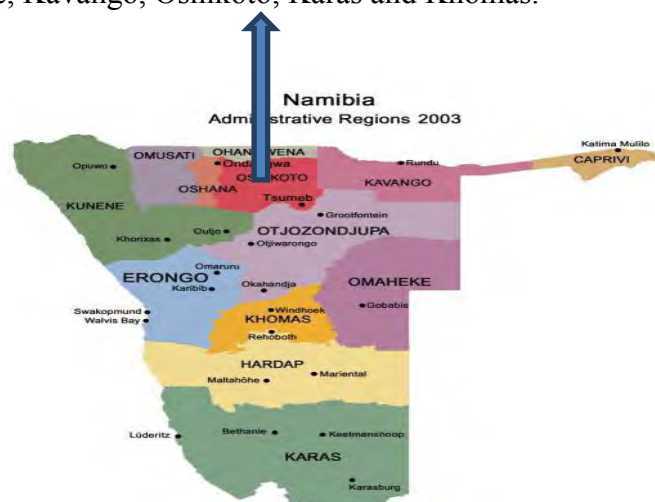


Figure 1. Showing the Namibian Regions

(Courtesy: www.namibiansafari.com/natravelMAP1.htm)

This research study was conducted in my school in the town of Omuthiya, a semi urban area in the northern central Oshikoto Region of Namibia. At this school there are 720 learners and 30 teachers, including a school Principal and three Heads of Departments. Thus, the teacher-learner ratio is 1:24. The school caters for learners from grade 8-12. Most learners come from the villages around the school while some come from as far as 15 kilometres outside Omuthiya. The school is under-resourced, for instance there is no laboratory or library. Science at my school is taught mainly theoretically, although on rare occasions teachers go the extra mile and do practical demonstrations. During my study, I used locally easily accessible materials and borrowed some chemicals from a neighbouring school for the practical activities.

A teaching and learning unit of work (see Appendix I) on acids and bases consisting of a series of lessons was designed and implemented in my grade 9 class. The topic on acids and bases was chosen because I wanted to explore learners' prior everyday knowledge and experiences regarding acids and bases in conjunction with practical activities.

1.7 Research limitations

The school that I have purposefully selected for this study does not represent the whole population of grade 9s in the town of Omuthiya, or of Namibia, and therefore the findings cannot be directly generalized to the larger population. The study was also carried out in a specific grade and on a specific topic, making it difficult to generalize.

Initially, I had planned to observe a teacher friend from a neighbouring school, to get some insight into how he approached the teaching of acids and bases in grade 9. However, due to time constraints that did not happen. Maybe my findings would have been different if I had done so.

1.8 Definitions of concepts

For the purpose of this study, this is how I have defined and used the following concepts:

Co-construction of knowledge: learners in their group settings discuss and come up with their own shared understanding of the subject learned with the help of the teacher.

Conceptual development: to develop learners' concepts concerning the topic at hand.

Learner-centredness: a teaching pedagogy foregrounded by the Namibian curriculum that informed my research.

Meaning making: to make sense of the subject matter being taught.

Mediating learning: a teaching method of helping learners to be fully engaged during the lessons by always giving them a task to do or to think about.

Scaffolding: like its namesake in the construction industry, scaffolding in education is a temporary support mechanism. Learners receive assistance early on to complete tasks, then as their proficiency increases, the support is gradually removed. In this fashion the learners take on more and more responsibility for their own learning.

Ombike: traditional Oshiwambo alcoholic liquor made from oombe, oombu, oontantahe and most of the (local) traditional fruits learners brought during the elicitation of prior everyday knowledge concerning acids and bases.

Ombeke: large sourplum (*Ximenia caffra*) – a local fruit which is very sour but edible, and a delicacy for young boys herding cattle.

PEEOE approach: an approach adapted from White and Gunstone (1992). POE stands for Predict, Observe and Explain and is a useful strategy for use during practical activities. PEEOE stands for Predict, Explain, Explore, Observe and Explain (Maselwa & Ngcoza 2003).

Practical activities (as opposed to practical work): a method of teaching science using easily accessible resources whereby learners are given worksheets with instructions on what to do next.

Prior everyday knowledge: the knowledge that learners possess which has been gained from their surroundings, from parents, friends and from previous lessons.

Prior knowledge: the knowledge and experience that learners have gained from previous grades or lessons.

ZPD: Zone of Proximal Development, a fundamental framework for explaining learning as increasing participation in a community of practice characterized by scientific inquiry.

1.9 An overview of the thesis chapters

This thesis consists of seven chapters:

Chapter One introduces the research, outlining its context and its motivation. The chapter details my role and interest in the study, and provides information on the purposes and goals of the study. I also provide an overview of the thesis chapters.

Chapter Two furnishes a review of literature relevant to the study. The literature reviewed is on learners' prior everyday knowledge and everyday life experiences in the teaching and learning of acids and bases, as well as on the role of practical work in science. This chapter also describes the conceptual framework which informed this study.

Chapter Three discusses the methodologies employed to frame, plan and carry out this research study. It also describes the study's research paradigm: the interpretive paradigm, within which a qualitative case study approach is adopted. Research site and sampling issues are discussed in detail. Data gathering techniques are described, as well as how the data were analyzed and validated. Ethical issues are also discussed in this chapter.

Chapters Four (phase one) & Five (phase two) present and analyze the data generated from the document analysis, observation of lessons by a critical friend, stimulated recall interviews with a critical friend, and focus group interviews with the learners. These chapters also highlight emerging categories from the processed data.

Chapter Six consists of the interpretation and discussion of the analyzed data presented in Chapters Four & Five, with reference to integrating learners' prior knowledge and addressing the research goal and questions. In this chapter, the findings of the study are presented in relation to some of the literature reviewed in Chapter Two, and an attempt is made to make meaningful knowledge claims relating to the research questions as outlined on Section 1.5 of Chapter One.

Chapter Seven concludes the study by providing a summary of the findings of the study, making certain recommendations arising from the study, describing the limitations of the study and suggesting avenues for future research. Being a reflexive and reflective practitioner I also included some personal reflections on my journey as a novice researcher.

1.10 Concluding remarks

Chapter One attempted to primarily to contextualize the study in respect of its locale and participants. It also seeks to provide a motivation for the research by discussing its goals and rationale before offering a brief overview of the thesis chapters.

The next chapter deals with the literature reviewed in this thesis relating to the integration of learners' prior everyday knowledge and experiences, and the role of practical activities in the teaching of acids and bases.

CHAPTER TWO

LITERATURE REVIEW

A large body of findings shows that learning proceeds primarily from prior knowledge, and only secondarily from the presented materials. However, prior knowledge can be at odds with the presented materials, and consequently, learners may distort presented materials. Neglect of prior knowledge can result in the audience learning something opposed to the educator's intentions, no matter how well those intentions are executed in an exhibit, book or lecture (Roschelle, 1995, p. 1).

2.1 Introduction

In this chapter, I discuss the literature that informed my study. The chapter focuses on specific basic aspects of the curriculum – the science curriculum in particular – and attempts to put into perspective the following:

- The Namibian curriculum's views on teaching and learning;
- The concept of prior everyday knowledge and practical activities;
- The role of practical activities; and
- The theoretical framework that underpins the study.

2.2 Namibian curriculum's views on teaching and learning: Learner-centered education

In Namibia, learner-centred education (LCE) is supposed to be practically oriented in all subjects (with special emphasis on the natural sciences), and is meant to include participatory and observation methods that conduce to reflection in and on practice (MBESC & MHETEC 1998, p.2). Learner-centred teaching is “based on democratic pedagogy, a methodology which promotes learning through understanding and practice directed towards empowerment to shape one's own life” (MBESC & MHETEC, 1998, p. 2). According to the policy document *Towards education for all* (MEC, 1993), teaching and learning is supposed to be organized in such a way that:

- The starting point is the learners' existing knowledge, skills, interests and understanding, derived from previous experiences in and out of school;
- The natural curiosity and eagerness of all young people to learn, to investigate and to make sense of the widening world must be nourished and encouraged by challenging and meaningful tasks;
- The learners' perspective needs to be appreciated and considered in the work of the school;
- Learners should be empowered to think and take responsibility not only for their own, but also for one another's learning and total development; and
- Learners should be involved as partners in, rather than receivers of, educational growth (p. 60).

Learner-centred pedagogy, therefore, "presupposes that teachers have a holistic view of the learners, valuing learners' life experiences as the starting point for their studies" (MEC, 1993, p. 83). Learner-centered pedagogy also entails a pedagogic approach in terms of which teaching begins with the interests of the learners, their existing knowledge, skills and understanding. Furthermore, it entails a pedagogic practice in which the learners' perspectives and contributions to the learning processes are highly valued.

A learner-centred approach recognizes all three curriculum arguments for the use of everyday contexts in science teaching, that is, building on sociocultural achievements, widening access, and promoting learners' empowerment. Nyambe (2008, p. 40) asserts that learner-centred education (LCE) means putting learners first, recognizing and building on knowledge, skills, abilities and experience, responding to their needs, taking into account the different ways in which they learn, and demonstrating respect for their language and culture. According to Nyambe (2008), if the teaching and learning environment takes cognizance of the learners' culture and language then they are more likely to comprehend and make meaning of the subject materials that are presented to them. This requires a thorough understanding of how teaching and learning are supposed to take place, and involves assessing the implications of change away from teacher-centred to child-centred learning, progressivism and constructivism (Thompson 2012, p. 49).

2.3 Conceptual Framework

2.3.1 The concept of prior everyday knowledge and its role in science

Roschelle (1995, p. 17) describes prior everyday knowledge as “raw materials to be refined”, this raw material being what learners already know about the topic or lesson to be learned. Prior knowledge can be viewed from two perspectives, that of the accomplished scientist and that of the learner.

From the perspective of learners, it could be argued that they come to class with different understanding and knowledge bases gained from different experiences. Such knowledge and experiences could help learners form new ideas during the teaching and learning processes. It is recognised, however, that this prior knowledge could be at odds with meaningful understanding of the subject matter as it is proposed in the epigraph above. Hence teachers need to clear up certain misconceptions pertaining to teaching and learning repertoires.

Roschelle (1995) asserts that learners’ prior knowledge empowers them to better understand current theories and practices during the learning process. Kibirige and Van Rooyen (2006) point to problems that can arise when teaching ignores learners’ everyday knowledge and value systems, arguing that, for example, learners’ enthusiasm and motivation can be diminished. It is therefore important that teachers start from where the learners are in order to facilitate their learning whilst preserving their enthusiasm and motivation.

To help learners make the most of new experiences, educators need to understand how their prior knowledge will affect their learning (Roschelle, 1995). That is, teachers need to design tasks that will enable learners to gradually develop new scientific concepts by making connections between the ‘old’ and the ‘new’ knowledge. Also, teachers need to be able to employ a variety of strategies to work with learners who bring a range of different experiences to the science classroom. Important among these strategies is the recognition that since science is something that we deal with every day, there must be ways of allowing learners to share and discuss their everyday experiences and link them with the school science content knowledge (Oloruntegbe & Ikpe, 2011).

Oloruntegbe and Ikpe (2011, p. 267) further suggest that building on the relevant experiences of learners from whatever background through a ‘place-based’ approach to learning within a framework of experiential education could heighten their motivation and enhance their performance in basic science. Stears, Malcolm and Kowlas (2003) also maintain that

learners' everyday knowledge should be used as a reference point in thinking about the nature of science, and as a context for applying scientific ideas and skills. Their research reveals that the use of everyday knowledge in the science classroom increases the levels of engagement of learners in the subject. Learners enjoy making links between their everyday experiences and science in the classroom when the curriculum is designed to facilitate such links. Stears et al. add that in order to acquire knowledge, learners should be actively involved in a community of (science) practice in the classroom.

But how does every day learning occur? Everyday knowledge can be constructed in a variety of ways, such as learning via television, learning from adults and asking questions about why we do certain things. "Research has indicated that learners often construct their own theories about how the natural world works, prior to formal science education, but their theories are frequently contrary to those of scientists" (Osborne, 2005, p. 37). Osborne (2005) points out that learners' self-constructed conceptions can contain misconceptions or alternative conceptions. These misconceptions or alternative conceptions might then create barriers to the learners' reception of the 'approved' explanations offered during science teaching and learning.

As noted in recent study by Rennie (2011), learners worked with every day or familiar substances (their everyday knowledge) and were expected to reflect, manipulate and make connections between these substances and the school/classroom science concepts or ideas). Rennie refers to this as blurring the boundaries between home and school science. This school of thought resonates well with the endeavours of my study.

Acids and *bases* are used almost daily in our homes in the form of products familiar to most learners. For example, wood ash is basic and *oombeke* [local fruits] and *oombu* [local fruits] are acidic. These materials might therefore serve as learning vehicles to both assist and motivate learners to understand the science of acids and bases. This knowledge comprises part of the cultural capital of my learners and deserves to be recognized.

In his study of learners' conceptual understanding of acids and bases, Demircioglu (2004) found that learners in their prior knowledge knew more about acids than they knew about bases. Although they had a good knowledge of formal descriptive aspects, they had inadequate conceptions of certain concrete phenomena, such as heat being released during an acid and base reaction. Demircioglu noted that learners found it easy to give examples of acids, the most frequently mentioned being hydrochloric acid, sulfuric acids and ethanoic

acid; but when asked to list the bases very few learners could do so. In addition, some of the learners described pH as “a measurement of the degree of acidity” (Domercioglu, 2004).

Ausubel (1968) cautions that although it is possible to memorize random strings of letters and numbers, education is intended to produce meaningful learning whereby new information is understood and can be applied. He goes on to suggest that meaningful learning occurs when the learner is able to make sense of the materials presented and what is being taught has some link with existing knowledge. Furthermore, the prior knowledge of the learner does not have to be accurate, for “if a learner holds frameworks for understanding that are at odds with the accepted knowledge, these alternative frameworks may act as suitable anchors for new knowledge” (Ausubel, 1968, p. 170). Of course, when a learner makes sense of the presented material in terms of an alternative framework, it might be a different sense from the one intended.

Roschelle (1995) notes that many research studies have been conducted on the subject of learners’ prior knowledge. These studies reveal that most learners enter science classrooms already holding ideas of possible relevance to the topic being taught, but these are most often ignored by their teachers. Also, it has been found that learners interpret new information quite easily to fit their existing ideas, and that during practical work they often see different phenomena from their teachers (Roschelle, 1995). The question then is, how often do teachers take into consideration learners’ prior everyday knowledge? And how should they go about doing this?

Roschelle (1995, p.1) further draws our attention to the fact that it is common practice for teachers to focus on the ideas they want to put across to their learners. Sometimes this approach is confounded when learners bring up their prior knowledge. Roschelle (1995, p.3) referring to Dewey (1964), therefore suggests that in this way “designers discover that which is problematic for the learners, and establish conditions that support the process of inquiry: *time, talk and tools*”.

This perspective is echoed by Davis and Linn (2000, p.820). Davis and Linn contend that reasoning about scientific phenomena in the classroom should be guided so as to reveal the learners’ own thinking. Secondly, the teaching and learning of science should make science accessible, and models that make sense to learners should be identified so that new information can be connected to prior knowledge. Thirdly, teaching should lend support to all learners so that new links and connections can be made from their own ideas and discussions.

Finally, learners should be encouraged to be responsible for their learning and also reflect upon their ideas and knowledge integration.

In summary, prior-everyday knowledge may or may not be accurate, and may come in different forms within different fields of study. Recognizing and engaging with prior knowledge assists in the learning process. But, as Roschelle (1997, p. 2) points out, there is much debate about how best to incorporate prior knowledge into lessons, and this is the question that this study sets out to address.

2.3.2 Mediation of learning

In mediating learning, teachers typically walk around to give groups assistance and give further explanations where learners do not understand (Sisovic & Bojovic, 2000). Sisovic and Bojovic (2000, p. 263) assert that “instead of transmitting the knowledge in its final shape, it gets formed in the process of learner-teacher, learner-learner and learner-teaching content interaction.” Roschelle (1997, p. 3) further explains that “Vygotsky emphasizes the role of social process in learning, suggesting that new concepts appear first socially, and only gradually become psychological. He suggests that curriculum developers should provide social models of appropriate activity, enable groups of learners to do more complex activities that they could handle individually, and use signs to enable people to negotiate the different meanings they find in social activity”. Roschelle (1997) thus proposes the following:

Developers must also remember that learning depends on social interactions; conversations shape the form and content of the concepts that learners construct. Only part of the specialized knowledge can exist explicitly as information; the rest must come from engagement in the practice of discourse of the community.
(p. 5)

The use of group work supports a learner-centered approach. The active construction of knowledge through social interaction and the interaction with the learning content provided by experimental work helps learners to develop cognition and understanding (Sisovic & Bojovic, 2000). Teachers ask questions to gain clarity regarding learners' prior-everyday knowledge. Learners are given a short summary on the chalkboard and also in hand outs.

Working in groups makes it easier for the learners to help each other when answering questions. Teachers walk around the class to keep learners' attention on the activities at hand. Learners are encouraged to share their prior-everyday knowledge about the topic, which helps them to develop scientific concepts on, for example, acids and bases. Furthermore,

cooperative learning in a group enables the exchange of knowledge and ideas among learners who may differ in their developmental levels and prior knowledge; it stimulates students to participate actively in the process of learning.

2.3.3 The teaching and learning of acids and bases

The concepts of acids and bases belong to the basic principles in the chemistry curricula. The way acids and bases have been explained has changed during the development of chemistry. New models are introduced that seek to give a better description of reality. The alchemists defined acids on the basis of their sour taste. “The way acids were explained developed stepwise until in 1810 when Davy proposed that all acids contained hydrogen” (Dreschsler & Schmidt, 2005, p. 20). Furthermore, “bases were seen as neutralizers of acids, but a common composition was not known” (Dreschsler & Schmidt, 2005, p.21). Dreschsler & Schmidt, (2005), further elaborate on the definitions of acids and bases:

At the end of the 19th century, Arrhenius introduced the dissociation theory, for which he was awarded the Nobel Prize in 1903. He connected the acidic properties to positively charged hydrogen ions (H^+). Acids were defined as substances that produced hydrogen ions in water solution. Bases were defined analogously as substances that produced hydroxyl (OH^-) ions in water solution. “Using the Arrhenius model, bases are thus limited to substances that contain OH^- groups. The Arrhenius model is also limited to water as a solvent. In the reaction between acids and bases water is formed and – as a by-product- a salt” (p. 23).

Previous research in science education shows how learners and teachers have struggled to understand the role of models in general as well as in chemistry (Justi & Gilbert, 1999, p. 200). Justi and Gilbert (1999) report that teachers use hybrid models instead of the specific historical models in their teaching. “Hybrid models result from a transfer of attributes from one model to another one” (Justi & Gilbert, 1999, p. 200).

The everyday meanings of words can also be a source of difficulty in understanding scientific concepts. For example, Schmidt (1991) showed that learners had difficulties understanding the concept of neutralization. Many learners believe that any neutralization reaction will always result in a neutral solution. He attributed part of this difficulty to the ambiguous use of the term ‘neutral’ in ordinary language and in the chemical context. For example, during the practical activities in my study I observed that instead of learners describing “the reaction between acid and base”, they said, “*we saw boiling taking place without fire*” and “*the smoke coming out when a metal is put into acids*” (see Chapters 4 & 5).

Lin and Chiu (2007, p. 775) agree that “language plays a crucial role in formal instruction. However, language in chemistry confuses students”. The main reason is that the meanings of certain terms in chemistry and daily life are different. Technically speaking, students should learn chemistry language in context so as to avoid confusing it with ordinary language. This means that teachers should help learners to acquire the vocabulary used in science subjects and make the learners realize that science language is not necessarily the same as everyday language. In the context of chemistry, the learning of the correct meanings of relevant terms should follow the acquisition of schemata (Lin & Chiu, 2007).

2.4 Role of practical activities in science

The teaching and learning of acids and bases involves practical investigations. Swain, Monk and Johnson (1999) argue that practical activities provide students with insight into the natural world. However, the efficacy of practical work depends on how teachers and students perceive activities and how they conduct them in the learning situation. Millar (2004) argues that the tasks must be designed effectively to enable students to develop various skills, as science is characterized as both the process and the product.

There is a widespread belief also that discovering things through experimentation is the “very essence of science” (Parkinson, 2002, p. 114) and that learners should be taught the fundamentals at school level. Parkinson’s (2002) argument has been further justified by the opinion that learners enjoy practical work and learn through seeing things happening. Therefore, given that the subject matter of science is the material world, it seems natural, and rather obvious, that learning science should involve seeing, handling and manipulating real objects and materials, and that the teaching of science involves acts of ‘showing’ as well as of ‘telling’ (Millar, 2004, p. 7). However, science teachers should be careful not to equate activity with learning: as Bodner (1986) cautions, you can teach well without any learning taking place.

But what exactly is the role of practical experience, then, and how does it aid understanding? According to Watson (2000, p. 58), there are several aims and goals for practical work, namely,

- To encourage accurate observation and description;
- To make phenomena or the abstract more real;

- To arouse and maintain interest; and
- To promote a logical and reasoning method of thought.

In Hodson's research (1990, p. 34), in which teachers were asked their reasons for implementing practical work in the classroom, the answers were, in most cases: to motivate by stimulating interest and enjoyment, to teach laboratory skills, to enhance scientific knowledge, and to give insight into scientific methods and develop certain 'scientific' attitudes, including that of objectivity. However, Hodson (1990) believes that such diverse and extravagant claims demand critical analysis, and he comments: "Not only may it be the case that some goals are better approached by other means, it may be that none of these goals of science education are best approached by practical work". He goes on to say: "No longer should we accept without question the science teaching profession's universal and unthinking approval of commitment to practical work" (p. 34).

Hodson (1990, p.34) then asks a number of questions in relation to practical work:

- Does practical work motivate children? Are there alternative or better ways of motivating them?
- Do children acquire laboratory skills from school practical work? Is the acquisition of these skills educationally worthwhile?
- What view/image of science and scientific activity do children acquire from engaging in practicals? Is that image a faithful representation of actual scientific practice?
- Does practical work assist children to develop an understanding of scientific concepts? Are there better ways of assisting this development?
- Are the so-called scientific attitudes necessary for the successful practice of science? Are they likely to be fostered by the kinds of practical work children engage in?

From my experience in the teaching and learning of science, some learners do enjoy the kinds of practical activities that are provided in class, but some do not. Hodson views this as contradicting teachers' expectations that the interest and satisfaction of learners always increases when the amount of practical work is increased.

Furthermore, some teachers would argue that practical work does not always lead the learners to the correct conclusions, and may cause confusion. As an example, I recall that in 2009 I was teaching expansion in solids. The syllabus suggests a practical activity called the “ball and ring experiment”. The experiment is based on the assumption that a metal ball will fit nicely into a ring before it is heated, and will not fit into the ring after it has been heated. This was in a rural area before I moved to a town school, so there was no Bunsen burner in the school and in fact no laboratory. We used a wood fire to heat the ball. What happened was that the ball could still fit through the ring after being heated. There was I, puzzled, and some learners even said I was lying to them.

The point is that if I had not tried the experiment learners might have understood the idea better. Now I had just created confusion in their minds and caused some doubt. Little did I then know that science is about why things are not working, and that the failure of my experiment could have actually led to more arguments as to why the experiment did not work. For example, was it because I was using firewood as a source of energy? I was so concerned with the learners’ questions and what they were going to think of me that I never thought to ask them why the demonstration did not work. Instead of finding out why the experiment did not work and discussing the possible cause of failure with the learners, I felt so bad that I just continued teaching without establishing clarity concerning the matter. I knew that I had left most of the learners in a pool of confusion, since in the textbook it is stated clearly that the ball would fit in the ring when not heated and would not fit when heated, but there I was, unable to explain why what happened had happened, and unprepared to give the learners an opportunity to explain and explore further (Maselwa & Ngcoza, 2003).

Practical work has also been criticized as being expensive in terms of both time and resources, particularly when teachers are under tremendous pressure to complete the syllabus so that their learners can do well in their final year examinations (Parkinson, 2002, p. 114). Parkinson (2002) found that some teachers even declare practical work to be simply not worth the time or effort due to concerns about safety and the possibility of litigation.

The main logical purpose of practical work seems to be the opportunity it affords for the physical illustration of scientific concepts. Millar (2004, p. 9), asserts that “the role of practical work in the teaching and learning of science content is to help students make links between two ‘domains’ of knowledge, that is, the domain of objects and observable properties and events on the one hand, and the domain of ideas on the other”.

Watson (2000, p. 60) believes that this is not easily achieved, arguing that “scientific theories are often counter-intuitive and have to be re-constructed in the classroom to fit the phenomena at hand”. There is a well-known Chinese proverb about doing and understanding that seems to have been reformulated by learners after doing practical work: *‘I listen and I forget, I see and I remember, I do and I am even more confused’* (Watson, 2000, p. 20). Is practical work the only effective way of teaching and learning scientific concepts? What exactly are its strengths and weaknesses?

2.4.1 The strengths and weaknesses of practical work

A closer look at a few of the aims of practical work will be taken in order to evaluate its strengths and weaknesses.

Increasing learners’ motivation to learn science

Practical work has been central in science education across the world, in some places for longer than a century (Duggan & Gott, 1996, p. 794). Throughout its history and development, it has been consistently advocated as a necessary component of science education. The arguments raised in its favour have been diverse and dynamic (Duggan & Gott, 1996), but teachers often argue that practical work can be used to stimulate learners’ interest and improve motivation (Hodson, 1990, p. 34).

Moreover, learners bring to science lessons their own ideas and experiences of scientific phenomena (Ramsden, 1994, p. 8). Learners have gained these experiences within their own unique backgrounds, be it pertaining to their interests, their parents’ interests, their home life, the impact of the media, and so forth (Turner & DiMarco, 1998, p. 87). Some learners are fortunate to enjoy the influence of ‘scientific’ homes, absorbing positive attitudes towards science: perhaps they were encouraged to fiddle with mechanical gadgets or nurture animals (Woolnough, 1994, p. 83). All these factors influence the overall interest a learner has in learning science.

According to Hodson (1990, p. 34), for some learners, successfully carrying out practical work induces a good feeling and a sense of satisfaction. However, research in the United Kingdom has shown that learners are not always motivated by an increase in practical work (Hodson, 1990, p. 34): this seems to depend upon the type of practical work that is done. For instance, for older learners there should be some cognitive stimulus, and not simply the opportunity to play in the laboratory that a young learner might enjoy (Hodson, 1990, p. 35).

Parkinson notes that “there is evidence that some girls react negatively towards practical work” (2002, p. 15), which may be because boys tend to overpower them and dominate during practical activities.

The promotion of practical skills through practical work

Hodson (1990, p. 35) states that, “arguments for practical work as a means for acquiring laboratory skills are of two kinds: those framed in terms of the acquisition of a set of ‘content free’, generalizable and those such as transferable skills such that are of value to all children.” These skills include the setting up of apparatus, measuring, predicting, observing, inferring and writing up practical reports.

Maselwa and Ngcoza (2003, p. 654) argue that learners find practical activities interesting and thus “become exposed to manipulating apparatus and thus acquire manipulative and observation skills”. This, they believe, stimulates learners’ interest in and understanding of scientific concepts. The widespread belief that science is difficult could be addressed by doing practical work. It has been argued that the relevant skills are important not only in science but in other subject areas as well.

Yet there is evidence that skills learnt in one subject cannot be transferred to another (Parkinson, 2002, p. 115). For instance, Hodson (1990) finds it difficult to see how the use of a pipette or burette maybe transferable to another subject or everyday life. There is also evidence that even after years of practical work, “learners are unable to perform simple laboratory procedures such as reading a pre-set ammeter, setting up a circuit board correctly, reading the volume of a liquid using a measuring cylinder *etcetera*” (Hodson, 1990, p. 36).

Hodson (1990) suggests that in a situation wherein complex skills are deemed necessary for further learning, a session before the practical work should be compulsory in order to teach these complex skills so as to ensure that all learners have sufficient skills to perform the practical work. It has been argued that certain skills are necessary only for the success of practical experiments, and perhaps the only skills that should be taught at all are those which are transferable to other subject areas and for further learning (Hodson, 1990, p. 36).

Perhaps the most important skill to teach is that of designing and implementing approaches to solve problems or investigate the abstract phenomena (Watson, 2000, p. 59). Hodson (1990, p. 36), further argued that “this is not intended to be an argument against teaching any laboratory skills”. It is rather an argument in favour of being more critical in the selection of

which skills to teach, and an argument in favour of making it clear to learners that laboratory skills constitute a means of engaging in other worthwhile activities.

Improving learners' understanding of scientific concepts through practical work

According to Hodson (1990, p. 36), empirical evidence concerning the efficacy of practical work as a way of acquiring scientific knowledge is difficult to interpret and somewhat inconclusive. Hodson further argues that, on balance, practical work cannot be referred to as superior to other methods. This is because practical work is often simply an illustration of what is in the textbook or the curriculum, done so as to assist the learners to visualize and remember (Parkinson, 2002, p. 115). Also, there is a tendency to equate activity with learning during practical work.

Thus teachers tend to use practical work as a kind of 'memory jogger' in order to facilitate discussion, which is pivotal to understanding (Parkinson, 2002). However, often with more complicated experiments, the 'noise' of the procedures used results in the meaning of the experiment being lost to the learners (Parkinson, 2002, p. 116).

In a study on practical lessons in a number of British Secondary Schools, Hodson (1990, p. 36) found out that children often performed experiments in class with only a faint idea of what they were doing, with virtually no understanding of the purpose of the experiment or of the reasons for the choice of procedures, with little reason for the choice of procedures, and with little understanding of the underlying concepts. It is therefore essential that in introducing practical work science teachers should be clear about the clear scientific concepts to be developed.

Although one of the more idealistic aims of practical work is to promote objectivity, it is more than often the opposite that occurs in a classroom scenario, where the need to get the right answers and to find out what ought to have happened dominates (Watson, 2000, p. 60). In the process, the scientific enquiry which scientific concepts are intended to promote is subsequently lost. What starts as an open-ended data gathering exercise degenerates into a pointless form of 'recipe following', as criticized by Hodson (1990, p. 37).

2.4.2 Alternative ways to engage learners in practical work

Hodson and Hodson (1998, p. 17) suggest several alternative ways of using practical work to complement the teaching and learning of science, including learning through apprenticeship and through scaffolding strategies (Lave, 1988; Hodson & Hodson, 1998). Lave (1988, p. 22)

argues that “apprentices learn to think, argue, act, and interact in increasingly knowledgeable ways with people who do something well, by doing it with them as legitimate, peripheral participants”. Hodson and Hodson (1998) further argue that if science education is a matter of enculturation into the beliefs, practices, values and style of discourse of the community of scientists, then students need the opportunity to work alongside and gain assistance, encouragement and support from someone who has already been successfully encultured into science. Apprenticeship is not just a process of internalizing knowledge and skills, it is also a process of becoming a member of a community of practice.

Apprenticeship can be combined with scaffolding, which “involves the teacher (or other more expert adult or peer) controlling the learning task so that the student is able to solve a problem” (Hodson & Hodson, 1998, p. 18). In a scaffolded learning situation, there is a purposeful interactive, instructional relationship between a teacher and a learner, such that the teacher takes responsibility for those elements of the task that are beyond the learner’s comprehension. Learners are helped to make meanings and links between the concepts rather than left alone to carry out practical activities while the teacher sits in front doing something under the pretense of being a facilitator. Leach and Scott (1995) echoed the same sentiment that:

Good science teachers do have deep understandings of both their students’ ways of thinking and the scientific perspective, and it is these insights which enable them to be sensitive to the varying intellectual demands of the school science curriculum and to support their students’ learning science (p. 51).

Hodson and Hodson (1998) assert that in a scaffolded task, such teacher assistance is only considered productive if the learner has fully comprehended the purpose and structure of the task, understands why particular strategies were used, and appreciates how the conclusion has been reached.

Thus the success of practical work as a way of teaching and learning science depends on the understanding of the part of teachers, teacher educators and curriculum planners of the theoretical frameworks that inform the practice. Maselwa and Ngcoza (2003) found that most learners do learn during practical activities in their classrooms, especially if practical activities are carefully planned so as to foster conceptual development. They also point out that practical activities can stimulate discussion and argument, which serve further to enhance learners’ conceptual understanding.

Practical activities should also allow elicitation of prior everyday knowledge, so that learners can make connections between their existing knowledge and the new knowledge (Stears, Malcolm & Kowlas, 2003; Oloruntegbe & Ikpe, 2011; Rennie, 2011). The elicitation and integration of prior everyday knowledge with practical activities will not only enable learners to enjoy science but will also promote curiosity about matters around them.

2.5 Theoretical Framework

This study is underpinned by the constructivist perspective. The constructivist perspective on learning has dominated research in science education over the past three decades (Rahayu, Kita & Ibnu, 2011, p. 1440). According to this perspective, meaningful learning does not consist in mere passive absorption of information but rather involves the active creation and modification of knowledge structures (Rahayu, et al., 2011). In other words, the learner is a responsible, active agent in his/her knowledge acquisition process.

The Namibian Curriculum (2010) points out that constructivism is a theory based on observation and scientific study about how people learn. Constructivist theory maintains that people construct their own understanding and knowledge of the world through experiencing things and reflecting on those experiences (Namibian Curriculum, 2010). Learning is considered to be a combination of an individual and social process that involves connecting new ideas and experiences to prior knowledge through interactions with the physical or social environment. Basically, this perspective stresses the thought processes of the learner and assumes that prior knowledge, attitude, motivation and learning style affect the learning process (Rahayu, et al., 2011, p. 1441).

Furthermore, constructivism involves the belief that meaning is constructed and not discovered (Gray, 2004, p. 17). Since people construct knowledge through and from their experience, it makes sense for prior everyday knowledge and experiences (see Section 2.3.1) to be used in the teaching and learning of science. In this study, two strands of constructivism are discussed, namely, the socio-cultural perspective and social constructivism.

2.5.1 Socio-cultural perspective

The four goals of education in Namibia are geared towards the learner-centred approach and thus seek to address the role of culture in education (MoE, 1993). One of the thrusts of

learner-centered education (LCE) is that teachers should begin with the known in order to move on to the unknown. LCE sees a learner as an active, inquisitive human being, eager to learn and to investigate in order to make sense of his/her surrounding world. Thus, the knowledge that the learner brings to school from home, the community and the environment should be utilized and drawn into teaching and learning.

McLoughlin and Oliver (1998, p. 128) describe socio-cultural learning theory as follows:

In socio-cultural theory the learner is regarded as an apprentice in a culturally defined, socially organized world. Intrinsic to this notion of apprenticeship is the recognition that asymmetric relationships are beneficial to the child's development. Adult child interaction scaffolds or assists the emerging competencies of the learner. Learning therefore becomes a form of assisted performance.

It is for these reasons that in my study I opted to elicit learners' prior everyday knowledge and experience and integrate it with practical activities so as to enhance meaning making, conceptual development and understanding regarding acids and bases. As research by Li (2010, p. 367) has shown, recognizing learners' cultural practices may help them to understand the subject matter.

Rennie (2011, p. 14) goes further in suggesting that "scientists and teachers need to work together, often on a regular basis, in such a way as to enable learners to experience 'real world' science and teachers need to stay in touch with a contemporary science outside of school". She further asserts that projects that promote science and scientists in schools and their communities can make a positive difference to students' engagement with and interest in science education.

According to Lemke (2001), the socio-cultural perspective implies thinking about science or doing science as a "human activity that is carried out within the institutional and cultural framework". In other words, the socio-cultural perspective entails situated learning and is about giving value to the role of social interaction in the teaching and learning of science. Lemke (2001, p. 301) thus suggests that "learners and teachers need to understand that science and science education are always part of large communities and their culture". Such acquisition of cultural knowledge in extending science beyond the classroom may help learners to make use of what they know in order to overcome obstacles to the learning task.

In the past, neglect of the socio-cultural perspective has resulted in science being viewed as static and absolute knowledge that is disconnected from culture and society. This was how it

used to be presented in most classrooms. In contrast, it is proposed in this study that science be viewed as a dynamic human activity, in line with Vygotsky (1978).

2.5.2 Social constructivism

Social constructivism views knowledge as constructed socially by human beings in working with one another (Janse van Rensburg & Lotz-Sisitka, 2000, p. 12), with the cultural understandings into which they have been socialized. One of the unique features of this approach is that learners are encouraged to work in groups or helped by an adult as it is believed that knowledge is socially constructed through the sharing of views and ideas.

McRobbie and Tobin (1997) assert that the social constructivist perspective on learning suggests that learners should have control over their own learning and be able to construct meanings for their experiences in terms of what they know at the time of learning (p. 199). The literature suggests that learners should be taught using a context-based approach to increase their participation in class and help determine what is to be learned and how is it learned (Pearsall, 1999; Gilbert, 2006). For example, one could make use of locally accessible materials in conjunction with conventional laboratory materials, which may sometimes be unfamiliar and beyond the range of learners' comprehension.

In social constructivism, emphasis is on the meaning making and understanding which comes out of social interactions. For instance, Vygotsky (1978) in his theory of the zone of proximal development (ZPD) observed that when learners were assessed on tasks in which they worked independently they did not do as well as they did when they worked in collaboration with others. This is because when learners work in collaboration with others they enter another level of discussion and argument, which leads to them making meaning of their learning processes and hence developing more appropriate knowledge. Vygotsky (1978, p. 90), noted that "an essential feature of learning is that it creates a zone of proximal development; that is learning awakens a variety of developmental processes that are able to interact only when the learners are interacting with people in their environment and in collaboration with their peers".

2.6 Concluding remarks

In this chapter I have explored the literature that relates to my study. It has been argued that practical work is not the only way of presenting science, nor necessarily the best way: care needs to be taken by teachers in terms of what, how and when to include practical work in

science lessons. It is also argued that teaching science using practical work acts as a source of motivation to learners, provided that the practical work is at an adequate level of complexity; that is, that the concepts are clearly conveyed, errors are understood, and skills are learnt to enable further learning.

I also briefly discussed practical activities in relation to the constructivist theoretical framework that informs this study, in particular, the socio-cultural perspective and social constructivism. An attempt was made to show how these theories impact on teaching and learning. In the next chapter I present the research methodology and research orientation that informed the study.

CHAPTER THREE

RESEARCH METHODOLOGY

Qualitative research is multi-method in focus, involving an interpretive, naturalistic approach to its subject matter. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings people brings to them (Dupuis, 1999, p. 45).

3.1 Introduction

The goal of my research was to investigate the integration of learners' prior everyday knowledge and experiences into practical activities on acids and bases, with a view to enhancing meaning making, conceptual development and understanding.

In this chapter, the research design and the methods used to carry out the empirical processes are described. The practical processes described here aimed to explore learners' prior everyday knowledge of selected concepts and their relational use during the learning of concepts and processes in science, in particular, acids and bases. More specifically, this chapter reports on procedures used to gather data on the integration of learners' prior knowledge and practical activities into the teaching of science (acids and bases).

3.2 Research paradigm

This research study is situated within the interpretive paradigm, an approach interested in "the meanings and purposes attached by human actors to their activities" (Guba & Lincoln, 1994, p. 106). The interpretive paradigm seeks to understand the meanings that people give to their own social interactions. It exposes how individual and group interpretations of reality influence people's intentions and actions (Winberg, 1997, p. 78).

Janse van Rensburg (2001, p. 16) asserts that humans understand the world as it appears to them: research knowledge is constructed in the minds of the people who are active in the research process. In understanding the phenomena under scrutiny, therefore, the researcher should interact with the participants, listen, cooperate and share their experiences. Appropriately, then, I was actively involved in the social context of the participants.

Cohen, Manion and Morrison (2007, p. 37) state that “interpretive researchers begin with individuals and set out to understand their interpretations of the world”. Interpretive research is therefore characterized by a particular ontology, epistemology and methodology (Terre Blanche, Painter and Durrheim, 2006):

Ontology specifies the nature of reality that is being studied, and what can be known about it. Epistemology specifies the nature of the relationship between the researcher and what can be known. Methodology specifies how researchers may go about practically studying whatever they believe can be known (p. 6).

The researcher working in this tradition assumes that people’s subjective experiences are real and should be taken seriously, and that we can understand others’ experiences by interacting with them and listening to them.

Within the framework of these assumptions, this research employed a case study methodology; specifically, a qualitative case study research approach was adopted (Stake, 2000, p. 242). Qualitative research seeks to obtain a holistic picture of what goes on in a particular situation, in this case, in my Physical Science classroom. It seemed the most appropriate approach as, according to Cohen, et al. (2007, p. 182), a case study “focuses on practice, intervention and interpretation with the aim of improving the situation”.

In my case, I explored the integration of learners’ prior everyday knowledge and experiences into practical activities in the teaching and learning of acids and bases. The case study also afforded me an opportunity to improve my own practice through being a reflective and reflexive practitioner.

Cohen, et al. (2007), further describe a case study as a specific instance that is frequently designed to illustrate a more general principle. This implies that a case study enables the researcher to develop a broader understanding of a particular phenomenon through interacting with people in such a particular case. Furthermore, in a case study the researcher gets in touch with a real situation and engages with the people in that situation, so as to listen to what they are saying or to observe what they are doing in relation to the phenomenon in question (Cohen, et al., 2007, p. 11).

Denzin (1989) points out that case studies will often be the preferred method for interpretive research because they are epistemologically in harmony with the researcher’s experience and thus provide him or her with a natural basis for generalization. But Clough and Nutbrown (2007, p. 127) argue that case study results are particular to a context and can therefore not be

generalized as they cannot be reproduced in different settings. I concur with these latter scholars: it was not my intention to generalize from my experience in this study, given that it was so context- and activity-specific.

Le Roux (2001) maintains that while the data acquired in a case study provides a description of current conditions, a series of case studies could reveal information that might help in forming a new idea for further research. This means that the results are not generalized but are nevertheless useful indicators of possible further research into the issues revealed. Similarly, the findings of this study will not be used to generalize how physical science teachers are supposed to integrate learners' prior everyday knowledge into their teaching *per se*, but will be used to generate recommendations for further research and improving practice.

3.3 Research orientation

As indicated earlier, the study is qualitative in nature. The qualitative approach was chosen on the basis of questions posed and the 'reality' in which the research was to be conducted. The reality referred to here (Burns, 2000, p. 3), is a social reality that is "a creation of individual consciousness, with meaning and the evaluation of events seen as a personal and subjective construction". In addition, the qualitative approach was chosen because of its ability to elicit information from written, spoken and observable activities (Taylor & Bogdan, 1998). This ability is deemed appropriate for exploring the integration of learners' prior everyday knowledge and experiences with practical activities.

In choosing this topic, I had hoped that learners would be encouraged to share their experiences pertaining to acids and bases, discuss some of their findings with their families, and acquire a scientific understanding of acids–bases related issues. Boud and Miller (1996, p. 68) suggest that "interpretivists are intrigued by the shared practices, beliefs and spoken and unspoken agreements among different groups and individuals which guide the society". Thus it was that I encouraged the learners to brainstorm and discuss the things they uses at homes which they thought contained acids and bases (Kuhlane, 2011). They were also required to research and record their findings regarding things they thought contained acids and bases. Clark and Ramahlape (1999, p. 112) believe that by introducing learners to the provisional nature of scientific knowledge in this way, we can counter the stereotypical image of science projected in conventional textbooks. In my teaching, a teaching and learning unit of work consisting of a series of lessons was developed so as to incorporate learners' prior knowledge (Appendix F). It comprised of 'hands-on', 'minds-on' and 'words-on' practical

activities using easily accessible teaching and learning support materials, as proposed by Maselwa and Ngcoza (2003). These researchers argue that practical activities minimize the memorization of scientific concepts and are useful in the promotion of conceptual understanding.

A good qualitative research design should, according to Janesick (2003, p. 45), be simultaneously open-ended and rigorous if it is to solve complex issues arising from the social setting under study. Research design “describes the procedures for conducting the study, including when, from whom and under what conditions the data will be obtained” (McMillan & Schumacher, 2001, p. 30). In other words, design indicates how the research is set up, what happens to the subjects and which methods of data generation are used. Its purpose is to provide, within an appropriate mode of inquiry, the most valid, accurate answers possible to research questions (McMillan & Schumacher, 2001).

3.4 Theoretical framework

This research study is informed by the constructivist perspective; in particular, the socio-cultural and the social constructivist perspectives (see Section 2.7). According to the constructivist perspective, one of the most important factors influencing learning is what the learner already knows. Thus, Ausubel (1968) suggests that teachers need to ascertain learners’ prior knowledge and use it as it is a starting point. According to Stears, Malcolm and Kowlas (2003, p. 98), consideration of learners’ prior everyday knowledge takes into consideration the socio-cultural background, which could help to make learning meaningful. Furthermore, it is recognized that meaning making takes place in a social context.

O’Donoghue, Lotz-Sisitka, Asafo-Adjei, Kota and Hanisi (2007, p. 435) confirm that “few educators would dispute that learning arises in diverse socio-cultural contexts of meaning making interaction”. These authors believe that such learning can strengthen social relationships across school and the community, and has the potential to develop as reflexive praxis in response to environment and health risk issues in a local context (O’Donoghue, et al., 2007, p. 435).

Moreover, the assumption that the mobilization and incorporation of learners’ prior everyday knowledge is pivotal in enhancing learning is embraced in our new Namibian curriculum and science syllabus (NSSCO/H 2010), and this is what triggered my interest in this study.

3.5 Research goal

This research study aimed to investigate the integration of learners' prior everyday knowledge and experience into practical activities on acids and bases, with a view to enhancing the meaning making, conceptual development and understanding of grade 9 learners in the school where I teach.

Research Questions

To realise this goal I endeavoured to answer the following questions:

- What prior everyday knowledge and experience relating to acids and bases do grade 9 learners bring to the science classroom?
- Does the elicitation and mobilization of learners' prior everyday knowledge and experience of acids and bases enable or constrain learner engagement?

The above questions were mainly answered by the use of brainstorming and discussion sessions. The sessions were observed and also videotaped for review with my critical friend.

- Does learner engagement enable or constrain meaningful learning?
- Does integrating learners' prior everyday knowledge and experiences into practical activities enable or constrain meaning making, conceptual development and the understanding of acids and bases?

To answer these questions, I depended mostly on evidence from audio and video transcripts and an observation schedule compiled by a critical friend. There were stimulated recall interviews with the critical friend who observed my lessons as well as focus group discussion with the learners. I also looked at my critical friend's reflections and the worksheets that the learners had to complete during the practical activities.

3.6 Research site and participants

My research study focused on a grade 9D class at my school, Endiki Secondary School in Namibia (pseudonym), consisting of 28 learners initially. There were 9 boys and 19 girls in this class, although one girl dropped out towards the end due to pregnancy. According to the school principal, unfortunately over the past five years the school had experienced a number of drop outs due to pregnancy.

Most of the learners in this class are repeating the grade. As a result, they are not motivated regarding their studies. Sadly, most teachers speak negatively about them because of their poor performance. This has affected their morale and they seem to have low self-esteem.

I am currently teaching Physical Science to this grade and hoped that involvement in this study would motivate them in their engagement with science. For instance, seeing themselves being videotaped and being trusted by the teacher to bring materials for the science lessons from home are privileges which in most cases are only given to the 'A' class.

I also took advantage of the fact that according to the syllabus acids and bases are introduced for the first time in grade 9. So, there would be no prior knowledge required from the previous grade. From my experience, teachers usually teach predetermined lessons from the textbooks or schemes of work. As a mediational tool in this study, I developed a teaching and learning unit of work from a variety of textbooks and other resources (rather than relying on snapshot lesson plans). I used it to teach my grade 9 class so that I could gain insight into how best to design my own learning and teaching support materials (LTSMs) (Czerniewicz, Murray & Probyn, 2000, p. 68), implement them and evaluate them, in order to enhance conceptual development. Also, in doing this research, I have begun to learn how to research my own practice.

3.7 Data gathering techniques

The data gathering techniques were: **document analysis, brainstorming and discussion; observation and videotaping of lessons, interviews, namely, stimulated recall interviews** with a critical friend and **focus group interviews** with the learners.

A variety of data gathering techniques was used in this study so that the techniques could complement one another. Cohen, et al. (2007) argue that the rationale for using different data generation techniques (a process known as triangulation) is to ensure the trustworthiness and validity of the data generated. For instance, “a methodological triangulation which can either be that one uses the same method on different occasions, or different methods on the same object of study” (Cohen, et al., 2007, p.141). I used the latter method.

Trustworthiness is the measure of consistency in the findings, to the extent that the enquiry could be replicated with similar respondents in the similar context by a different researcher (Lincoln & Guba, 1985, p. 290). Similarly, Cohen, et al. (2007) argue that many studies in the social sciences are conducted at one point only in time, thereby ignoring the effects of

social change and process: hence the need for different methods on the same study objects, in order to ensure validity (see Section 3.9). The table below represents the data gathering techniques used in this research study

Table 1. Data gathering techniques

Phases	Research Questions to be answered:	Methods used to gather data and sequence of activities	Data to be gathered	Purpose
Phase 1	<i>What prior everyday knowledge and experiences related to acids and bases do Grade 9 learners bring to the classroom?</i>	Document analysis; brainstorming and discussions.	Different prior everyday knowledge and experiences of learners on acids and bases. Various substances that learners use at their homes that they think contain acids and bases.	To elicit learners' prior everyday knowledge and experiences on acids and bases. Background to assist me in preparing the lessons, so as to help to move from abstract to context.
Phase 2	<i>What prior everyday knowledge and experiences related to acids and bases do Grade 9 learners bring to the classroom?</i>	Lesson planning and prior review with a critical friend.	Science curriculum, input from critical friends.	Create lessons that incorporate the principles guiding the study, e.g., use of every day knowledge, relevant activities etc.
Phase 3	<i>How does integrating learners' prior everyday knowledge and</i>	Observation and video-taped lesson	To gather data on all areas of the intervention and classroom activities	To provide data for analysis. To involve learners

	<i>experiences with practical activities facilitate conceptual development of acids and bases?</i>	Practical activities- worksheets.	Learners will do the practical activities using the locally available materials and later using the laboratory chemicals.	in the practical way of learning science rather than a teacher demonstrating to them.
Phase 4	<i>How does integrating learners' prior everyday knowledge and experiences with practical activities facilitate conceptual development of acids and bases?</i>	Stimulated recall interview with my critical friend who will observe my lessons.	After the data from observation are gathered, a follow up interview with a critical friend will be conducted. Questions to be asked will depend on the gathered data.	To gain insight on how my critical friend perceives the integration of learners' prior everyday knowledge and experiences enhance conceptual development.
Phase 5	<i>How does integrating learners' prior everyday knowledge and experiences with practical activities facilitate conceptual development of acids and bases?</i>	Focus group interview with learners.	Question to support the data already generated, gain learners' views on the inclusion of their prior knowledge in science class, their involvement in practical activities and how it helped them understands acids and bases.	Triangulate the data gathered from other techniques. To get views on the best approach to science that enable learning.

3.7.1 Document analysis

Document analysis was used to gather baseline data in this study. Ary, Jacobs and Razavieh (2006, p. 454) emphasize that document analysis can provide the researcher with information about prevailing situations. For this phase, the National Curriculum Statement for National Syllabus Grades 8-10 and textbook sections were analyzed in order to understand how acids and bases were presented. I ascertained that in the intermediate phase (5-7) there is no coverage of acids and bases, while in the senior phase the acids and bases topic is introduced in grade 9 instead of grade 8. Furthermore, the syllabus states that the use of **everyday substances** is important when teaching acids and bases, which served to confirm the potential value of my study (see Chapter 4).

3.7.2 Brainstorming and group discussions

Brainstorming was used to elicit learners' prior everyday knowledge and experiences of what they use at home in relation to acids and bases. "Brainstorming is a group creativity technique by which a group tries to find a solution for a specific problem by gathering a list of ideas spontaneously contributed by its members" (Denscombe, 2007, p. 167).

I thus asked the learners to present and discuss their prior everyday knowledge and experiences on acids and bases. Each learner in the group had to write down one or two ideas that were later collated to form a mind map.

3.7.3 Observations and video-taped lessons

Practical activities and worksheets

All my lessons were observed by my critical friend and videotaped. An observation schedule was used by my critical friend to record whatever was going on during the lessons. Cohen, et al. (2007) claim that observational data help the researcher to generate information from a real situation or context, and thus enable him or her to engage with and comprehend the described situation.

The purpose of these observations was to investigate how I elicited and integrated prior everyday knowledge and experiences during practical activities using easily accessible resources commonly used at home. I also used conventional science apparatus and indicators such as litmus paper, phenolphthalein solution, hydrogen chloride solution and so on, so as to compare them with the easily accessible resources commonly used at home. With the help of

videotaped lessons, I hoped to see how learners interacted and shared their views with others in their various groups. I was also hoping to see how they interpreted and understood concepts associated with acids and bases.

Since there is no laboratory at our school, learners carried out practical activities in the classroom using worksheets in groups designed to follow the Predict, Explain, Explore, Observe and Explain (PEEOE) approach as proposed by Maselwa and Ngcoza (2003) (see Section 2.6). These researchers assert that the PEEOE approach can be very useful, for instance, for consolidating and developing learners' understanding of acids and bases, by asking them to predict what would happen in a given situation, then to create the situation and, if their prediction was wrong, to explain and explore what they could now observe. Details of what happened are discussed in Chapter Four. The worksheets helped me to understand whether engaging learners in practical activities enabled or constrained them in making sense of scientific concepts in relation to acids and bases.

3.7.4 Interviews

Stimulated recall interviews

I chose stimulated recall interviews because of their flexibility. According to Lyle (2003, p. 862), "stimulated recall interview is a family of introspective research procedures through which cognitive processes can be investigated by inviting subjects to recall, when prompted by a video sequence, their concurrent thinking during that event". This gave me immediate access to what went on in the classroom during teaching and learning, and in the process helped validate my data (see Section 3.10).

Lyle (2003) claims that the value is enhanced when there is immediacy of recall, consonance between questions and cognitive organization, and indirect means of introspection in complex interactive contexts, such as the classroom. The normal procedure is for a recall or probe technique to be used to generate or facilitate the participants' thinking during the episode being played. The general pattern employed was a series of semi-structured but relatively open-ended questions posed to the participants as soon as possible after, or during the viewing of the videotape (Lyle, 2003, p. 863).

Some studies note that stimulated recall interviews can be a problematic methodology (Lyle, 2003). Lee (1992, p. 876) expresses a general concern about supplementing incomplete memories, and acknowledges the possibility that the participant might react to what was

viewed on the videotape, rather than recalling the taped episode. The narratives produced from stimulated recall interviews may thus not represent the conscious or unconscious cognitions taking place at the time of videotaped episode (Lyle, 2003, p. 864).

The stimulated recall interviews were conducted with the critical friend at my school, after observation of the lessons, and in conjunction with reflection while we watched the videotaped lessons. These interviews were audio-taped and transcribed verbatim.

Focus group interviews

Focus group interviews are described as “contrived settings, bringing together a specifically chosen sector of the population to discuss a particular given theme or topic, where interaction with the group leads to data and outcomes” (Cohen, et al. 2007, p. 378). Based on the above explanation, focus group interview with learners was then conducted after the lessons in order to find out how they had experienced the lessons and what scientific concepts they had learnt.

Cohen, et al. (2007) further state that the contrived nature of focus group interviews can be both their strength and their weakness. The discussions are spontaneous yet sharply focused on particular issues, therefore yielding insights that might not otherwise have been available in straightforward interviews. They are economical as far as time is concerned, producing a large amount of data in a short period of time, but they tend to produce fewer data than interviews with the same number of individuals on a one-to-one basis.

In each focus group interview I asked questions in English and translated them into the learners’ vernacular, which is Oshiwambo. I also let the learners speak in the language they were comfortable with. The reason is that I wanted learners to express their opinions, ideas and true feelings about how the lessons were, rather than possibly distorting these by having them speak a language in which they are not fluent or proficient. Most learners spoke in Oshiwambo. I then asked them to translate what they had said into English. During the transcription, I also translated the learners’ Oshiwambo version into English (Sections 5.4) and this became a useful validation process (Section 3.9). It could also be an area for future research: how language skills can be enhanced in science classrooms.

3.8 Data analysis

Data analysis is the process of making sense of and finding meaning in the data, interpreting what has been seen and what has been said (Gay, Mills & Airasian, 2006, p. 205). Qualitative analysis is a relatively systematic process of coding, categorizing and interpreting data to provide explanations of a single phenomenon of interest. In this study, data sets were colour-coded to assist me in making sense of them and identifying themes and patterns.

According to Cohen, et al. (2007, p. 462), “early analysis reduces the problem of data overload by selecting out the significant features for future focus”. My data analysis therefore commenced after the first data gathering tool was employed and was an on-going process until all the data gathered from the three instruments had been analyzed. Inductive analysis was applied, which according to Danermark, Ekstrom, Jakobsen and Karlson (2002) typically consists of identifying similarities in a number of observations. Patton (2002, p. 41) describes inductive analysis as the investigation of data to discover patterns and themes, resulting in a creative synthesis. Through the use of inductive analysis, categories and patterns emerge from the data, rather than being imposed on them prior to the gathering process (Davies, 2007).

During this process of analysing the data, I looked for trends, similarities and contradictions. I distinguished less important data from significant data by highlighting them with different colours (coding). For example, I used green for scientific concepts, red for misconceptions, and so on. Merriam (2001, p. 164) posits that “coding is nothing more than assigning some sort of short-hand designation to various aspects of your data so you can easily retrieve specific pieces of the data”. I then grouped together similar themes emerging from the different data gathering techniques and thereafter constructed analytical statements (see analytical statements in Chapter 6).

3.9 Validity and trustworthiness

Gray (2004) explains that validity is ensured if the research instrument measures what it is intended to measure. Cohen, et al. (2007, p. 133) assert that “validity is an important key to effective research. If a piece of research is invalid then it is worthless. Validity is thus a requirement for both quantitative and qualitative/naturalistic research”.

To enhance validity, the information was triangulated by comparing codes across the data sets generated by all three data gathering tools, before themes were developed. I also employed member checking to verify the accuracy of responses from participants. According to Cohen, et al. (2007, p. 136), “member checking is when the respondent validates, to assess intentionality, to correct factual errors, to offer respondents the opportunity to add further information or to put information on record; to provide summaries and to check the adequacy of analysis”.

I therefore gave my interview transcripts and summaries of discussions back to the critical friend in order for her to verify the responses. I also returned the transcriptions of the focus group interviews to the learners, and asked them to translate what they had said in Oshiwambo into English.

3.10 Ethical considerations

Cohen, et al. (2007, p. 246) describe the respondents as “subjects and not objects of research that need to be respected”. They suggest that respondents should be asked for their informed consent to the research, reserve the right to withdraw at any time, and be given a guarantee that the research would not harm them in any way. Murray (2006) emphasizes that consideration of ethics is of fundamental importance to all research, while Merriam (2007, pp. 212-13) argues that “ethics begins with the conception of the research project and ends with how we present and share with others what we have learned”.

The ethical issues of confidentiality, anonymity, voluntary participation and the right to withdraw were conscientiously addressed in this study. Before the research was conducted, I obtained permission from the Regional Education Directorate through the Inspector, from the school principal, from the Physical Sciences teacher (critical friend), as well as from the learners’ parents since my learners were still minors (see Appendices). I ensured that the identity of the participants was protected by using pseudonyms, and that the data generated by my research was kept confidential. After the research I promised to give my school, my Principal and the Inspector a copy of my thesis so as to build trust for future research purposes.

3.11 Limitations

The school which I have purposefully selected for this study does not represent the whole population of grade 9s in Namibia, or even in the town of Omuthiya, and therefore the findings cannot be directly generalized to the larger population. The study was carried out in a specific grade on a specific topic, making it difficult to generalize across grades.

Initially, I had planned to observe a critical friend from a neighbouring school, to gain some insight into how he approached the teaching of acids and bases in grade 9. However, due to time constraints that did not happen. Perhaps my findings could have been different if I had done so. Given another opportunity I would really love to observe and engage with how other teachers might approach this topic.

3.12 Concluding remarks

In this chapter, I described the processes involved in gathering the data that I used to answer my research questions. In any research study it is important to use the appropriate design and methodology to achieve credible and reliable research outcomes (Cohen, et al., 2007, p. 183). On the basis of the questions posed for the study, it was deemed appropriate to use an interpretive design. Likewise, qualitative methods were found to be the most relevant to elicit learners' prior everyday knowledge and experiences in conjunction with practical activities in the teaching of acids and bases. Ethical considerations were dealt with considered and certain limitations recorded.

In the next two chapters, the data generated are presented and analysed.

CHAPTER FOUR

DATA PRESENTATION AND ANALYSIS: PHASE ONE

In qualitative studies, researchers gradually make sense of what they are studying by combining insight and intuition with an intimate familiarity with the data, and this is often a difficult process. Most people inexperienced in qualitative research have difficulty in recognizing patterns in their data. There is no simple formula for identifying themes and developing concepts (Taylor & Bogdan, 1998, p. 142).

4.1 Introduction

In the previous chapter I outlined the research methodology of my case study. Various aspects of the methodology were discussed. Five data gathering techniques were used: document analysis, brainstorming, videotaping of lessons and observation, stimulated recall interview with my critical friend, and focus group interviews with the learners.

The focus of this chapter is to present, analyze and discuss the data. I also describe how the document analysis and brainstorming techniques were implemented during the data gathering sessions, and challenges that were encountered along the way.

4.2 Document analysis

4.2.1 The syllabus

The syllabus is the policy document that should inform and shape all teachers' teaching. It provides the guidelines on what teachers should teach in order to develop learners' understanding of specific topics as well as the general objectives that learners should achieve. The main aim of the syllabus in the Natural Science area is "to provide basic scientific background for our learners with the hope of producing the much needed scientists for the country" (NIED, 2010, p. 1). Namibian society needs to be scientifically literate if they are to cope with the challenges of appropriate global technology (NIED, 2010).

The subject Physical Science, within the Natural Science area, promotes the following aims in the curriculum guide:

- To develop knowledge, understanding, creativity, practical and experimental skills as a solid foundation for academic training to prepare learners for creative and meaningful adult life;
- To help learners to develop self-confidence, self-knowledge and understanding of the world in which they live, through meaningful scientific activities; and
- To develop a lively, questioning, appreciative and creative intellect to enable learners to discuss issues rationally, make careful observations and analysis, think scientifically, solve problems and apply them to tasks. (NIED, 2010)

It is also expected that by the end of the junior secondary phase (grades 8-10), learners will be well versed in basic science. According to this document, the topic of acids and bases is only to be introduced in grade 9.

Acids and bases appear under the theme of Environmental Chemistry. Quite interesting is the fact that acids and bases are not part of the curriculum throughout the junior phase; that is, acids and bases are taught neither in grade 8 nor in grade 10. For the purposes of continuity, one might have expected this topic to be taught across the phase.

Table 2: Showing the summary of the overall learning contents for Grade 8-10, Physical Science

Grade 8	Grade 9	Grade 10
Scientific processes and Experimental techniques		
Topic 1 Scientific processes	Topic 1 Scientific processes	Topic 1 Experimental techniques
Matter and Materials		
Topic 2 Matter	Topic 2 Matter	Topic 2 Matter Topic 3 Materials
Environmental Chemistry		
Topic 3 The gases of the air	Topic 3 Acids, alkali (bases), metals and non-metals	Topic 4 Environmental Chemistry.
Mechanics		
Topic 4 Forces	Topic 4 Mechanics	Topic 5 Mechanics-work, energy and power

Electricity and magnetism		
Topic 5 Electricity	Topic 5 Electricity and Magnetism	Topic 6 Electricity and magnetism
Waves, Sound and Light		
		Topic 7 Waves, Sound and Light

(Source: NIED, MoE, 2010, p. 5)

As I have said, acids and bases are not taught in grade 8. The section on acids and bases only begins in grade 9 and is divided into 22 different topics. I believe that to cluster all these different topics under acids and bases at the same time might be confusing for learners and even for teachers, given the fact that learners are being introduced to the topic for the first time. The confusion might be exacerbated by there not being enough time to go through the whole syllabus and by learners not having adequate background knowledge. Like other topics, the introduction to acids and bases should have begun in grade 8 and been spread throughout the junior phase. In grade 9, learners could then be introduced to more advanced topics, such as reactions between acids and metals, acids and carbonates, *etcetera*.

Here are the themes and topics that should be covered:

- **Acids and bases:** learners should be able to identify and name examples of acids or bases in everyday life; be aware that acids are common in foods, particularly fruits and that they have a sour taste;
- **Neutralisation:** acid's metal reaction and acid's carbonate reaction; and
- **Metals and non-metals:** properties of metals and non-metals.

As a result of there being too much content to be covered in grade 9, I believe that learners may not understand the processes and concepts involved very well.

The syllabus also suggests certain practical activities, approaches or demonstrations to be carried out by learners under the guidance of teachers.

- Acids:
 - Investigate the properties of acids (e.g. their effects on indicators such as litmus papers and universal indicator);

- Make simple indicators from flowers;
 - Investigate the reaction with a metal and carry out a test for hydrogen evolved;
 - Investigate the reaction of acids with a carbonate and carry out a test for the carbon dioxide evolved.
- Alkalis (bases):
 - Investigate the properties of alkalis (e.g. their effect on indicators such as litmus and universal indicator);
 - Investigate the reaction of acids with alkalis;
 - Demonstrate the acidity of soils and the use of lime to neutralize the soil; and
 - Measure the pH of a variety of solutions, place them on a pH scale and classify them as acids or bases.

Looking at the objectives and the basic competences described, learners' everyday knowledge and experiences should be considered. However, the examples given in the basic competencies indicate that acids are common in fruits such as oranges, lemons and apples, and these fruits are not well known or easily accessible to most of our rural learners in Namibia. For bases, the syllabus states that they are common in cleaning agents such as Jik, dish washer, *etcetera*, which are also not easily accessible to the learners. To follow these examples might result in teachers presenting acids and bases to learners without considering their prior everyday knowledge and experiences, which will characterize science as detached from the learners' world. Being from a rural setting myself (born and bred there), I remember how difficult it was to get an apple or an orange. As for cleaning agents, ash was our main cleaning agent for dishes or putting the *etiti* (a plate made from clay) over the fire, the thinking behind that being that the bacteria would be killed by heat.

Document analysis has offered some insight into the level at which acids and bases should be taught in the junior phase. In my view, the teaching of this topic would be better served if it started from grade 8 with a basic introduction and then continued throughout the phase in order to help learners understand the concepts more thoroughly.

4.2.2 Textbooks

Two textbooks were analysed to look at how the topic on acids and bases was presented. The first textbook analysed was *Go for Physical Science Grade 9*. It was written in 2007 by Helene van Niekerk and published by Macmillan, Namibia. The second textbook was *New*

Physical Science Grade 9, Namibia Junior Secondary Certificate, written by Ivan Britz and Nevison Mutasa in 2007 and published by Zebra publishing, Namibia.

The second textbook is very popular in terms of usage by schools in Namibia, while the first one is in most cases used by teachers for reference purposes, and only at some schools. The second textbook is popular because it contains activities for learners, such as projects to do, and describes how the tasks are to be done. I assume that is why most teachers like it, as it is more user-friendly in terms of preparation. It is also recommended by the National Institute of Education Development (NIED) for use in both public and private schools.

Go for Physical Science Grade 9

This textbook does include the topic of acids and bases. The language used and the content is suitable for this grade as it gives everyday examples of substances associated with acids and bases, such as vinegar, fruit, salt, milk and bicarbonate of soda. It could be concluded that this textbook does promote the use of everyday substances in teaching science lessons on acids and bases.

Furthermore, I think that this textbook is designed to promote Learner-Centred Education (LCE) as it encourages interaction and involvement on the part of learners during lessons. Also, the use of accessible resources in science is intended to make learners view science as something they are familiar with.

The contents regarding acids and bases in this textbook are as follows:

- Properties of acids and bases;
- Classifying substances as acids, bases or neutral;
- Detecting acids or bases using indicators;
- Make your own indicator using red cabbage; and
- Reaction of acids and bases.

New Physical Science Grade 9

This textbook is one of those designed to cater for the new Curriculum 2010. It puts emphasis on the use of everyday examples of acids and bases. It also gives examples of conventional laboratory acids and bases such as hydrochloric acid (HCl), nitric acid (HNO₃) and sulfuric

acid (H_2SO_4), and bases such as sodium hydroxide (NaOH), calcium hydroxide ($\text{Ca}(\text{OH})_2$) and ammonia (NH_3).

The learning content regarding acids and bases includes:

- Acids and bases (everyday examples);
- Detecting acids and alkalis (bases);
- Measuring pH;
- Making a pH indicator using plant materials;
- Practical activities on acids-bases reactions; and
- Preparation of salts.

However, if one examines the contents of these topics in detail, one soon realizes that the everyday examples referred to are still out of reach for the learners in my school community.

Although it has pictures, these are only monochrome, and I feel that vivid visual support for the text to aid comprehensibility is particularly important for learners studying science (especially in a language that is not theirs).

The language used in this textbook is average and vocabulary is at the level of the learners' thinking capacity. However, the textbook does not have a glossary or word boxes clarifying meanings of unfamiliar concepts. As a result, most of the science terms or concepts could potentially remain unfamiliar to learners.

4.3 Brainstorming and discussion (eliciting learners' prior everyday knowledge)

As I said in Chapter 3, the brainstorming session was the starting point of my research study. This session was aimed at answering my research question one and two, which are:

- What prior everyday knowledge and experiences related to acids and bases do grade 9 learners bring to the science classroom?
- Does elicitation of learners' prior everyday knowledge and experiences on acids and bases facilitate learner engagement or not?

During the brainstorming session, I worked with twenty-seven grade 9 learners divided into five groups of five learners per group and two groups with six learners. No specific criteria were followed in allocating learners to groups. They were all seated in such a way that they faced each other but at an angle from where they could read the chalkboard without having to turn round. Each group was given a worksheet with three focal questions. I wanted learners to list substances that they thought were acidic or basic. These were substances that were used in many homesteads. The purpose was to find out if learners were already familiar with such substances.

Learners were also provided with newsprint on which to write down things they thought contained acids or bases. During the discussion, I asked the learners some open-ended questions so that each group could read out what they had written. I started off with the general question such as: *What do you do with the dishes after supper has been served?* I had to code-switch to make sure the learners fully understood the questions.

From their responses, I noticed that learners were not familiar with what acids or bases were. However, after giving them a hint such as anything that has a sour taste or anything that can be used to clean, they then came up with the following:

Acidic substances

- *Ombeke* (Sour plum)
- *Onkenkete* (Buffalo thorn fruit)
- *Oombu* (a sour-sweet fruit)
- *Ontantahe* (a local sour-sweet fruit)
- *Ooshe* (a local wild fruit known to be a delicacy for San people)
- *Oonkwiyu* (Cluster figs)

All the fruits listed above are wild fruits that are found in the forest surrounding their homesteads. All of them are edible by humans and they do have a sour taste even when they are ripe. Interestingly enough, with regard to most of the fruits above, learners stated that they were also used to make *ombike* (a traditional Oshiwambo alcoholic beverage which is very strong) and this is reflected in the excerpt below.

Excerpt 1 Brainstorming session (BS)

- T: *“Okay it’s eaten by everyone again”*
- L: *“Okay, hmmm and good”*
- L: *“To make ombike”*
- T: *“To make what”?*
- L: *“Ombike”*
- T: *“Ombike? So one can make ombike with this one”*
- L: *“Yes, even eeshe”*
- T: *“Even ooshe can make ombike”?*
- L: *“Yes, even ombe”*
- T: *“So even ombe can make ombike”*
- L: *“Yes”*
- T: *“Meaning all fruits can make ombike”?*
- L: *“No, only some”*
- T: *“only some”*
- L: *“Yes”*
- T: *“oooookay”*

While some of ‘conventional’ fruits were mentioned by learners, they struggled to identify them. In the next excerpt one learner even mentioned vinegar as a fruit, which indicates how unfamiliar these substances are to them.

Excerpt 2 (BS)

- L: *“lemons”*
- T: *“lemons, good, what else”*
- Yes my dear”*
- L: *“Vinegar”*
- T: *“Vinegar, is Vinegar a fruit”?*
- L: *“NO”*
- T: *“so we are talking of a fruit, a fruit that is very acidic, shafa shili sour nga kashona ngii very acidic, eee”*

Apart from lemons what else sho hatulande mostola”?

L: *“Orange,Pawpaw,Lemons,Green apples,Oranges,“Vinegar”*

Basic substances

- *dish washer*
- *omutoko* (wood ash)
- *mbundjambundje* (a smelly and slippery plant that grows naturally in the Mahangu [millet] fields) and is used to clean dishes
- *elyata* (a thorny plant that grows in wild forests and can be used for cleaning dishes as well)
- *kanangalambandje* (a small wild plant)
- *katangakamuthithi* (a small wild plant that also grows in the Mahangu field)

After a little bit of scaffolding, learners were able to come up with locally available items that they thought contained bases. However, it was very clear to me that it was the very first time that the learners had encountered these terms, acids and bases. As one can see, none of the common laboratory acids or bases was mentioned.

There were also more interesting stories that the learners came up with. For example, one learner stated that, *'we can use soil to clean dishes'*. And as I asked further a learner stood up and said *'by using loam soil'*. Learners further expatiated by saying loam soil was mixed with small stones and shaken in the container to clean it and remove the bacteria:

Excerpt 3 (BS)

L: *“Take small stones in the container and shake it so that some bacteria’s that are in the container will get out”*

T: *“So you can just take what? Stones”*

L: *“Small stones”*

T: *“Small stones”*

L: *“small stones put them in the container”*

T: *“and put them in the container you want to wash, okay”*

L: *“you start shaking”*

T: *“then you start shaking”*

- L: *“The bacteria in the container can get out”*
- T: *“the bacteria can get out”?*
- L: *“Yes”*
- T: *“let’s say for example, siku ndjono okwali tamuli onyama yina ofeti nee? (literally, if that day you have eaten a fat relish) So ofeti ndjiya the fat can also go out if you put the stones”?*
- L: *“stones! Ya you can put stones with some sand”*
- T: *“oohoo, stones than you mix with some sand than you remove the fat”?*
- L: *“yes”*
- T: *“oohoo interesting”*
- L: *“or the hot water”*
- T: *“or the hot water. Stones, sand and hot water”*
- L: *“ya”*
- T: *“To remove fat”*
- L: *“Ya, to remove fat”*
- T: *‘interesting, really interesting*
- To remove fat, small stones will call it special stones + sand and then roll it over the container, very interesting*
- Okay and with me here than we have, we talked of acids, an acid only or descriptions aeee, mention different type of fruits that are available in our local environment?*
- So everybody knows nee? Now ngu ina popyasha, (literally, who did not say anything today?) yes”.*

Soil does not remove bacteria from the dishes; instead, it could only remove fats. During the discussion, learners also defined acids as substances that had a sour taste or something that could make one thin. I probed further on the thinness, and a learner said that she used to see her ‘auntie’ drinking vinegar so that she could be thin. This is a misconception about acids based on the test for fats, because when an acid is added to fats it emulsifies it. My argument was that one could not know what goes on inside the body when one drinks it. And bases are substances that could make one vomit when eaten.

The lesson was very lively and learners were eager to talk freely. This might be due to the fact that they realized that things that are locally available could also be discussed at school.

Almost everybody had something to say. Towards the end of the brainstorming session, a learner stood up and asked if a base in Physical Science was the same as a base in Mathematics. What was good about this question was that the learners were starting to see the possible overlaps in the subjects they were taught or possible differences in the definitions and meanings of terms between subjects. However, instead of re-directing the question to the entire class, I just explained it myself. See the excerpt below.

Excerpt 4. (BS)

T: Any questions?

L: It's like I met one word in mathematics talking the same like base.

T: oooh... the mathematic bases? ... Thank you very much

You guys should still go and ask your mathematics Teacher ne..... But ngeenge atu popi o base, momwaalu... we talk of Indices: Paife oha pu kala ne pena onamba himwe yili pevi, nokanamba okashona ke li pombanda ... (5²). Okanamba okashona its index and the bigger one is called Base.... Then in mathematics we say five to the power 2. Then soooo, base in mathematics does not mean the same like in physical science... alright Omu uvitekoo (literally translated; do you understand)?

L: Yes

T: But very good for asking

C.T: There is also a base, like in English word, pekota lyoshiima,

T: Very good ... very good

C.T: I think then it will be similar to the one in mathematics.....

T: To the one in mathematics ne....?

C.T: yes

T: Thank you soo much... Shaashi moshingilisha, base ohaku ti opekota...shi... shi onomola momwalu haku ti obase.. a Paife a kuti nee, ntano opekota lyambali. But you must still ask your math's teacher on this one. (Literally translated: this is because base in English may mean at the bottom of something, therefore its five at the bottom of two)

Is that clear?

L: Yes Sir

T: Then I will see you tomorrow, thank you so much.

4.4 Observation by a critical friend of the brainstorming session

The critical friend observed my lessons after which we watched the video together. She made some general comments, such as that the learners were enthusiastically involved in the lessons. Learners were writing their ideas down on newsprint and presenting them to the whole class. They discussed and shared ideas on what acids and bases were, and the organization of the lesson allowed them to participate. She also offered some very specific comments on elements of the lessons.

What follows is exactly what she had written down. I also include my guiding questions on the observation schedule.

Excerpt 5

Observation schedule by a critical friend

1. How was learners' prior everyday knowledge elicited?

“Teaching methods used: questions and answer.

Learners were asked to mention locally available things that contain acids and bases. Learners mention things generally, such as ondantahe, oombeke, oombu, mbundjambundje and Katanga kamuthithi. Learners were asked to categorize them into acidic and the basic ones. Acidic were such as; oondantahe have sour taste and basic ones are ombundjambundje and Katanga kamuthithi used for washing”.

2. How were teaching and learning materials used to teach acids and bases?

“Locally available materials were used to define bases and acids, and then linked to the definition in the books. Example; hydrogen ions are the ones causing the acidity in the fruits”.

3. How were learners scaffolded to make sense of the scientific concepts on acids and base?

“After the whole class has said acids have a sour taste as a property, the teacher then asked learners to find other properties of acids and bases based on what they have brought in the class”.

4. Could you suggest ways on how I could improve my teaching in order to enhance meaning making on acids and bases?

“You could have brought in some lemons and oranges for learners to compare these with indigenous fruits”.

5. General comments: reflections on the lesson

“Good you started with learners prior knowledge, learners used own knowledge to define acids and bases. This was very interesting lesson to observe, learners were very happy. I am looking forward to the next lesson, to see how litmus paper will prove that ash ‘omutoko’ (wood ash) as a base”.

My critical friend indicated that the learners were excited by the references to local materials, but pointed out that I might have brought in other fruits such as apples or oranges, and some alkaline products, for learners to compare their acidity and alkalinity with that of the local materials.

4.5 Concluding remarks

This chapter presented the data from the document analysis as well as elicitation of learners' prior everyday knowledge and experiences on acids and bases and some parts of the observation by a critical friend. The data revealed that learners were familiar with materials that are sour or taste bitter but did not know that there were acids and bases. Furthermore, learners mentioned local fruits that are related to acids and bases, but did not seem aware of more conventional acids and bases. The document analysis also revealed that learners are introduced to acids and bases for the first time in grade 9, and yet are expected to go into some details. In the next chapter I present the data from further observations of practical activities by my critical friend, focus group interviews and stimulated recall interviews and discussions.

CHAPTER FIVE

DATA PRESENTATION AND ANALYSIS: PHASE TWO

To know is, in some sense, to transform the object of knowledge. If we can understand meaning and, by doing so, improve our understanding of meaningful learning, then we will be in a position to improve education (Bettencourt, 1993, p. 39).

5.1 Introduction

As explained in Chapter 4, the purpose of the first phase was to present and analyze data from the document analysis as well as the elicitation of learners' prior everyday knowledge and experience pertaining to acids and bases. The second phase presents and analyzes data on how learners integrated their prior everyday knowledge and experiences into practical activities. These data sets are derived from the observation by a critical friend during the practical activities, which was followed by stimulated recall discussion while watching the video, and a focus group interview with the learners.

5.2 Observation of practical activities by my critical friend

I started my series of lessons with practical activities. During the first 10 minutes, I distributed the apparatus and showed learners how it was to be used. After the brainstorming session, the learners presented local resources brought to class which they thought contain acids or bases. I brought in some conventional chemicals obtained from a neighbouring school, such as hydrogen chloride solution and nitric acid solution. I also had some sodium hydroxide solution and lime water (calcium hydroxide solution), and brought in white vinegar from home.

The reason for this approach was that I wanted learners to make comparisons based on what was in the textbook when doing the testing of acids and bases. Each group was given clear instructions to follow. Although our school does not have a laboratory, I explained to the learners the basic laboratory rules and how to work with chemicals. Thereafter, I gave my learners worksheets on which to fill in what they observed during the practical activity, using a Predict, Explain, Explore, Observe and Explain (PEEOE) approach (Maselwa & Ngcoza, 2003).

I took learners step-by-step through the activity and this helped to ensure that all groups understood what was expected of them. After the activities were completed, all the groups presented their findings to the whole class. I then summarized the findings on the chalkboard so that we could compare and discuss them.

As the learners were giving feedback on their findings to the entire class, I had to help them use the correct concepts or terms. For example, most of them wrote that, when an acid is added to zinc, “acids make zinc to boil and I saw a smoke coming out” instead of that the acids reacted with zinc and a gas was released or evolved. In doing so, I was making sure that the correct concepts were learnt. See the excerpt below.

Excerpt 6 Practical lesson’s transcripts (PLT)

T: Then take ombeke, to test it if it’s acid, squeeze some juice out put it on the blue litmus paper, and see. Do it, and tell me what happened?

Lrs: Ooh,..... aaye,..... (Learners disbelieve)

L: Sir, this is just because ombeke oyina okala yiili ngawo (because ombeke is already red)

T: OkThen take phenolphthalein, check utale kutya, mo acids oha yi kala ngeipi?(what colour will it be in acids?)

Lrs: Colour do not change but sir aaye.....(learners disbelieve)

T: Just do it....., do it and then we see?

Lrs: Okala (the colour) remain the same oo, oo, oo, laughing.....

T: Is that one now clear that our ombeke and oombu are acidic.

Lrs: Yes, mhh.....

My critical friend had this to say:

Overall, the practical activities drew learners’ attention and stimulated them to want to find out what would happen next. Learners were able to make sense of the content learned. The practical activities help the teacher to explain more as learners were asking question such as ‘how’ and ‘why’. It also gave an opportunity for learners to debate, hence acquiring more skills and knowledge especially when their everyday prior knowledge and local available materials are incorporated during the teaching and learning. Learners constructed their own meanings and were encouraged to think critically by the teacher’s thought provoking questions. Learners learned from each other by sharing ideas, hence exposing learners to new concepts and enriching their vocabulary.

This has shown me that if we teachers were to teach every day using easily accessible materials, learners would make sense of what is taught and understand the concepts involved. Learners were able to differentiate between acids and bases. Learners also were able to relate the textbook definition of acids to what they have experienced during the practical activities. Such teaching methods also promoted a sense of belongingness and togetherness among learners, and hence collaborative learning.

Here are some of the combined written comments from my critical friend's observation sheet:

Excerpt 7

1. How were learners' prior everyday knowledge elicited?

Questions were asked to refer back to which resources were collected on acids and bases. Learners were shown the two litmus papers, red and blue. Learners were also shown universal indicators and test tubes to be used. The common lab acids and bases were also brought in by the teacher since we do not have a lab at our school. I guess the teacher borrow them from neighbouring school.

2. How were teaching and learning materials used to teach acids and bases?

The teacher showed learners how red/blue litmus paper work, by dipping it on a liquid and it turned blue. Learners got worksheets where they filled in spaces during the experiment. Used litmus papers to prove that the solution is an acids or a base. Blue litmus paper dipped into hydrochloric acid result (blue litmus paper turned red). Testing for hydrogen makes a pop sound. And for CO₂ turn light off. Indigenous fruit were also tested, such as oombeke (tested if its acidic, take blue litmus paper to ombeke blue litmus paper turned red) ombeke put in a phenolphthalein solution, the solution remained colourless. The practical activities enabled learning of acids and bases because litmus papers were used to prove that these locally available resources if they are acids or bases.

Learners could have collected more ashes and fruits and do experiments in smaller groups, e.g. of four. This was super! I did not know that oombeke are acids (I could not believe it before) until the test was done. Thank you for promoting our indigenous fruits, that they are effective in teaching science.

The practical activities helped enable the learning of acids and bases. The learners were very active in the lessons and very inquisitive. Indicators were used to prove that locally available materials were acids or bases. My critical friend was also thrilled by the (red) colour of *ombeke* disappearing in the presence of phenolphthalein, just like conventional acids and bases do.

Among the problems associated with the practical activities observed were that some learners were too quiet in their groups and just waited for others to provide answers and discuss the topic. Also, the critical friend mentioned that I had too many local fruits, which created chaos in the class as each learner wanted to try out what he or she had brought. She also observed that some learners dominated their groups and wanted to do the practical activities alone. Since the number of learners was not that big, only 27, she thought that it would have been better to have worked with smaller groups consisting of three learners.

5.2.1 The test

The test was based on the topics taught during these lessons and it was out of 30 marks. I wanted to assess the learners' understanding of acids and bases. I concentrated on they were making their points and their explanations in answer to the questions.

The test was in two sections. The first section was multiple choice and the second consisted of structured questions where learners had to fill in some missing words, define some concepts, and give some examples of acids and bases.

Overall, I was happy with the performance, although there were still some misconceptions to be cleared. For instance, I found out that some learners could not link their prior everyday knowledge to the 'conventional' examples of acids and bases. As a result, I fear that in future they might go on giving *ombeke*, *Ontantahe* and *elyata* as examples of acids and bases. For me this is valid localized knowledge but these substances are not internationally known as acids or bases.

Nonetheless, the test revealed that the elicitation of learners' prior everyday knowledge and experiences had been successful. However, conceptual development and meaning-making still needed further polishing.

In summary, seven learners got 25%-30%, twelve learners got 42%-49%, six learners got 50%-60% and two learners got 70% in the test.

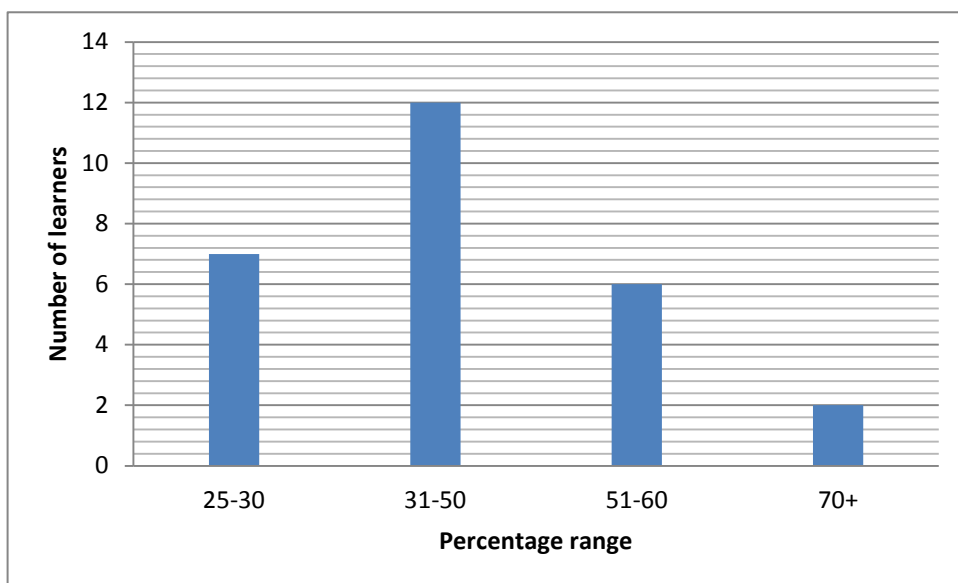


Figure 2: Showing the performance of learners in the test

5.3 Stimulated recall interview (SRI)

From the stimulated recall interviews with my critical friend when we watched the video, I noticed that she was giving answers spontaneously to issues at hand. In her responses there was a tendency for her to equate all prior everyday knowledge to indigenous knowledge, and to assume that it results in learning. She also said that learners' prior everyday knowledge was well elicited, from known to unknown (see the extracts on brainstorming session). This helped the learners to be active throughout the lessons. Lesson plans were well structured and continuous. And asking questions constantly made learners attentive in the lesson.

Another point that came up was that I tended to give more attention to the girls than to the boys. My response was that my class had many more girls than boys (9 boys vs 18 girls). This is the transcribed text of the interview:

Excerpt 8 (SRI)

LK: *Yes good evening Ms, thank you for agreeing to do the stimulated recall interview with me, when you watching the interview or the...the lessons aa.... how do you feel about the way I elicited the learners prior everyday knowledge?*

T: *Aaa that was very excellent (LK: uumh),. aam, by the way you did it like you started first with, the learners going to collect materials that are available locally, then and from there they brought them it to the class, then they have to categorize bases and then the acids (LK: uum), you could see really that they were so interested in knowing what was going to follow next.*

LK: *Okay*

LK: *Aa... any further observation you made again?*

T: *Aa.... any other observation is just that indigenous knowledge/prior knowledge is very important, cos... then when we teach learners things that they find in textbook, they may not really understand the whole content for example that one of acid and basis cos if you started maybe with textbook theory, (LK: iyaa), it was going to be very (LK: ok) difficult to them to grasp.*

LK: *Ok*

LK: *And how were the teaching and learning materials used then, the one the learners collected, did they, did I tried to use them in proper way or how, how, what is your view?*

T: *Yes, you tried..., for example I..., I remember where you took ash then you mix it with water, you trying to test if ash is a really a base or is it an acid, or is not true that is a base you see that learners could not really believe it even if they know that it is used for washing, so you mixed it there then you put the.....the litmus paper then it turn blue.*

LK: *Turn blue*

T: *Iyaa*

LK: *AndUum, what are your thought about this theory of teachers trying to integrating what learners already know, into their teaching and learning, is it really help full or do you think we should just stick to our old traditional teaching?*

T: *Aaa this issue or the way of incorporating indigenous knowledge for me is really helping, like when I was seeing, aah, I was like, at first I'm like is it really going to work, but I, I at the at later stage I was also one of those one who were enjoying the lesson.(LK: ok) So one it really brings joy to the classroom , (LK: ok), and it, it, it makes all the learners to be aa engaged and then it also helps us at least to, to believe that our..... our knowledge or our material we have can also be used to learn not just only what is in a textbook sometime those, those acids and bases may be very expensive so we may not afford, so it's really helpful, (LK: ok)*

LK: *And do you think really it also help the learner to develop some of the scientific concepts that are from their local environment, apart from what they are already have in their textbook?*

T: *Uum may be aa (LK: um) may be aa when they continue further (L:iyaa), with science (LK: ok), iyaa, because they will always remember like ok in grade 9 this is what we did, (LK: ok), I think they will, (LK:ok) uum*

LK: *Ok, alright*

LK: *Uum, just one more, then we go now and what did I even scaffold the learners to help them understand what they already knew that can be a scientific one because aaah.. sometime we tend to just say hydrochloric acid is the acid and sodium hydroxide is a base but we do not try to link, now how was the linkage, how did I link the what the learners brought or know to the scientific concept?*

- T:** *Iyaa, I, what I can remember is aa like at first when you were trying to now describe generally from what the learners know, what is now what are bases and what are acids, and I remember they were saying nooo.... acids are things that have sour taste, then you when you went to base.. . and say no aa.. they are things that we use to wash with at home, then from there they brought the stuff then that is when you went to the textbook, then later on again then ok then you went to the textbook to ss now to to make link with what is written in the textbook then what is aa the learners know, then from there, that is when you gave them a task to go and complete a questions. For me (LK:iyaa), that was a scaffolding, (LK: ok) to go through with them at first and later on let them do it to discover more on their own.*
- LK:** *On their own*
- LK:** *Alright, thank you just hold on for your a while-----*
- LK:** *And what do you think learners aa aa what are the learner prior everyday knowledge that they then brought to the classroom, did they bring with anything that they knew but they did not know whether it was acid or base but all they knew they use it home but they never really had an idea?*
- T:** *Like, ok, in like we know that in the forest we found these all indigenous fruits like oombu, oombe, they know then when they brought it to the class, when you said they should go and collect it oo oo (LK: oombeke) oombe yes they know it's something that has a bitter taste..like ooh..what is this..aa... ombeke, that one is one the most bitter taste. (LK: ok) iyaa and then again they also know that those aa material like katagakathithi (LK: ok) and others can be used for washing (LK: iyaa) and ash also can be used for washing, (LK:ok) but they just did not know that is a base (LK: it was base or acid), iyaa.*
- LK:** *Ok, so the onus should be up on us on teachers to try to help them to bring to connect the link or do you think is not needed we should just concentrate on what is in the textbook.*
- T:** *NO, aam I believe (LK: uum) this only that I do not know why others Namibian teachers like I (LK: iyaa) was never trained on that use of indigenous knowledge maybe is not existing within the Namibian Curriculum, which I think is really needed. So one can make use of it instead of just teaching learners what is in the textbook while they have resources that are surrounding them in the community you can make use of it and I think is really interesting because learners will not even forget.*
- LK:** *Ok, and do you think now using what learners know or using their prior knowledge with a practical activity or like the demonstration that you observing there really helps to open up the learners understanding?*
- T:** *Yes it helps, (LK:ok), iyaa, (LK:ok), I, I still want to go back (LK:ok) to that as (LK:iyaa) uum, so it, it really helps because aa the learner will just know, ok, when it was tested I remember it was ash mixed with water, then tested by putting the red litmus paper then turn reee..d.... turn blue, so that tells one that is a base, now mixing the characteristic and then indigenous knowledge that is really help.*
- LK:** *Ok, and maybe generally, your general comments overview on what I have been doing for the past weeks anything positive, bad, anything I mean yaa, tell me to improve and what to do, general comment.*

T: *Ok, so..... that was really good, you really help the learners and I think aa I just have to touch on the issue of gender (LK: yes) I think you were more on the girls, I do not know why (LK: hahahaha), then you left out some boys so but then.....girls first. (LK: some boys, some boys I was not really giving attention to the boys). No, that is what I have observed, then I thought maybe, since you are man you are trying to be gentle. (LK: hahahaha) Iyaa*

LK: *Ok, oo otherwise what was*

T: *Otherwise it was fine, I think you should keep on doing it, even not just with that grade you should just.... involve the learners send them out what is there then that is what make science so interesting, I think maybe you should also tell other teachers it should not only be with science subject even on other science subjects other..... in other subject that are not science there is always resources out there that we can use instead of been focusing on what we can buy sometimes we do not have money at the school (LK: ok), iyaa*

LK: *So you are suggesting at least if there could be a campaign to just sensitize (T: iyaa) all the teachers also (T: indigenous knowledge) to try to make use of what the learner already knows.*

LK: *Ok, now thank you so much Ms for your time and for everything*

T: *You welcome*

LK: *Thank you!*

My critical friend reported that learners' prior everyday knowledge and experiences were elicited very well. Learners were really eager to find out what would happen next. Teaching and learning was made easier by the learners' enthusiasm and their wanting to find out if the locally available materials that they had brought to class were acidic or basic.

She further explained that integrating what learners already know into teaching and learning was a helpful method as learners were likely to remember what they had brought to class and relate it to what the teacher had taught as reported by Renie (2011). Moreover, she suggested that if teachers in Namibia could start teaching integrating their learners' prior everyday knowledge and experiences into their lessons, then the understanding and development of concepts would be enhanced. Learners should be involved in the lessons fully from the word go and co-construct knowledge. And the teachers' role should be to facilitate the co-construction of knowledge and meaning-making.

5.4 Focus group interview

This interview was first conducted with the learners in English. When I realized that they could not express themselves sufficiently well in English I then interviewed them again in Oshiwambo (their mother tongue). They were then able to understand the questions and hence talked freely. The interviews were done after I had finished teaching the lessons. As I pointed out in Chapter 3, the focus group was aimed at enabling me to gain some insight into whether incorporating learners' prior everyday knowledge with practical activities enabled or constrained meaning making with regard to acids and bases.

Since the lessons started by looking at learners' prior everyday knowledge and experiences, I wanted the learners to tell me how they felt about my teaching strategies, how the lessons were, and what they learnt during the lessons.

Appendix J shows some excerpts from an interview with a focus group. I have included learners' translation of Oshiwambo into English and my translation of learners' Oshiwambo into English.

As far as the focus group interview is concerned, the whole process was very interesting and the learners even mentioned that it was amazing to see that their local fruits could be brought into the classroom for learning purposes. Learners commented that they learned new concepts that they did not know before, such as neutralization, reactions, and indicators and so on. They also explained that they did not know that their local fruit could contain acids or bases, as was proven when the experiment on testing for acidity and alkalinity was done.

Learners further said that the lessons were very lively as they were involved during the activities. The practical activities were interesting, especially the one that involved the materials they brought from their homes. For example, the practical activity on bases using *omutoko* (wood ash) changed colour to purple and in *ombeke* (sourplum) the red colour changed to colourless in the presence of phenolphthalein.

Learners also suggested that acknowledging what they knew and integrating it into teaching and learning should happen in all subjects, not only in science. Furthermore, teaching and learning in groups encouraged participation and learners learned from each other. They further said that they enjoyed the practical activities, especially seeing the smoke coming out of a test-tube although there was no fire. One learner even promised not to fail Physical Science again!

5.5 Concluding remarks

In this chapter I presented and analysed data from the observation of practical activities by a critical friend, the focus group interview with the learners and the stimulated recall discussion. It was clear that learners were actively involved throughout the practical activities since they were using familiar resources. Having a video camera during the practical activities and in all lessons proved worthwhile. The different themes and findings that emerged from this data are discussed in the next chapter.

CHAPTER SIX

DATA INTERPRETATION AND DISCUSSION OF FINDINGS

Data analysis is probably the most difficult aspect of qualitative research to communicate to others. Many people who are new to the methodology are capable of establishing rapport in the field, asking questions and recording data, but get stuck when it comes to analyzing their data. And if we can understand meaning and, by so doing improve our understanding of meaningful learning, then we will be in a position to improve education (Taylor & Bogdan, 1998, p. 140).

6.1 Introduction

This chapter discusses the findings of the study, according to the themes that emerged from the data gathered. Firstly, two Physical Science textbooks and the national syllabus document were analyzed with reference to how acids and bases are presented for the learners to make sense of this topic. Secondly, brainstorming sessions were used to elicit and mobilize learners' prior everyday knowledge and experiences on acids and bases. Thirdly, observation by a critical friend was intended to find out how learning took place when everyday materials familiar to the learners were utilized during the teaching and learning of acids and bases. Fourthly, stimulated recall discussion with my critical friend and a focus group interview with the learners took place, yielding further insight into the approaches used in the study. Last, but not least, some concluding remarks are made.

6.2 Themes that emerged from the data

The themes that emerged from the stages of data gathering reported in Chapter Four (Phase 1) and Five (Phase 2) are discussed in relation to the relevant literature reviewed in Chapter Two. The themes that emerged during the data analysis process were analyzed using open coding (Section 3.8).

With regard to open coding, Bohm (2004, p. 271) argues that: "researchers use their background knowledge about the context of the textual passage being investigated and, in general terms, their knowledge about the area of investigation". Leedy and Ormrod (2010, p. 143) maintain that during open coding data sets are divided into segments and then

scrutinized for commonalities that reflect categories or themes. After the data are categorized, they are further examined for properties that characterize each category.

In general, Leedy and Ormrod (2010) are of the view that open coding is a process of reducing the data to a small set of themes that appears to describe the phenomenon under investigation. Open coding and data analysis help facilitate the interpretation of the data gathered. The following themes emerged:

How do the selected grade 9 Physical Science textbooks present the topic on acids and bases?

- Textbook 1 did mention the use of locally available materials but in a minimal way. It could be argued that its emphasis is on conventional science examples. Textbook 2 is very popular in terms of usage in Namibian schools. This could be attributed to the fact that it has already designed activities and teachers find it user-friendly. The use of everyday resources such as examples of acids and bases are also evident in this textbook.

The Physical Science Syllabus

- The Physical Science syllabus promotes the use of everyday examples and materials when teaching science. I also found out that acids and bases are not taught in grade 8, which is the starting grade for the junior secondary school phase in Namibia. Instead, learners are introduced to the topic in grade 9 only, for in grade 10 the topic is not really emphasized or foregrounded.

Elicitation of learners' prior everyday knowledge

- During the brainstorming sessions (the elicitation and mobilization of learners' prior everyday knowledge and experiences), it was evident that learners knew of materials that were sour, bitter or used as cleaning agents, but were unaware that those materials/ resources were acids or bases.

Learners' engagement and participation

- During the observation and stimulated recall discussion, it was observed that learners were actively participating and that my mediation of learning had been effectively done.
- Practical activities are a good way to stimulate learners' motivation and encourage learner engagement.

Language issues

- Although not the subject of my study, the issue of learners' language proficiency was an emergent theme as well.

The following analytical statements were derived from the data analyzed from the various data sources used in the study and further informed by my research questions. These are presented in Table 3 below.

Table 3. Data sources, themes, analytical statements and research questions answered.

Data source	Themes	Analytical statements	Research question answered
Document analysis	Curriculum issues	The promotion of local available materials in the two physical science textbooks is at minimal level and their emphasis is on conventional science examples.	I used this tool to gather my baseline data to inform my Research Questions
Brainstorming sessions (elicitation and mobilization of learners' prior everyday knowledge and experiences)	Learners' prior everyday knowledge and experiences	Learners did not know that their local everyday substances (e.g. fruits) were acids or bases.	What prior everyday knowledge and experiences related to acids and bases do grade 9 learners bring to the science classroom?
Brainstorming sessions, observation of lessons by a critical friend and focus group interviews	Mediation of learning	The facilitation of learners' participation and engagement	Does elicitation and mobilization of learners' prior everyday knowledge and experiences on acids and bases enable or constraint learner engagement?

		Integrating of learners prior everyday knowledge and experiences with practical activities enable or constrain learners' understanding of scientific concepts on acids or bases and learner engagement.	Does integrating learners' prior everyday knowledge and experiences with practical activities enable or constrain conceptual development and understanding of acids and bases?
Observation of lessons by a critical friend, stimulated recall discussion and focus group interviews	Practical activities and learner engagement	Learner engagement during practical activities enhances the co-construction of knowledge and meaningful learning. Enhancement of learner talk and argumentation during science lesson.	Does learner engagement enable or constrain to co-construction knowledge and meaningful learning? Does integrating learners' prior everyday knowledge and experiences with practical activities enable or constrain conceptual development and understanding of acids and bases?

Table 3: Showing the analytical statements

Furthermore, the themes and analytical statements that emerged from the analyzed data are discussed with a view to answering the main research questions of the study, as set out in Chapters One and Three.

- What prior everyday knowledge and experiences relating to acids and bases do grade 9 learners bring to the science classroom?
- Does the elicitation and mobilization of learners' prior everyday knowledge and experiences on acids and bases enable or constrain learner engagement?
- Does learner engagement enable or constrain meaningful learning?
- Does integrating learners' prior everyday knowledge and experiences with practical activities enable or constrain meaning-making, conceptual development and understanding of acids and bases?

6.3 Discussion of findings

6.3.1 Document analysis

Analytical Statement 1: How acids and bases are presented in two Physical Science textbooks and curriculum documents.

Acids and bases are around us and they are almost an indispensable part of our lives. They are used daily and yet the textbooks that I analyzed do not take that into consideration. In one of the textbooks, the first statement on the topic of acids and bases is as follows: “There are groups of substances which are called acids and bases. The activities below will reveal the properties of acids...” (van Niekerk, 2009, p. 64).

This leaves the teacher not knowing how to introduce the topic appropriately, and this could have a negative impact on the learners as some of them might not be familiar with the examples given. Roschelle (1995, p. 17) proposes that, to help learners make the most of new experiences, educators need to understand how prior knowledge affects learning. That is, teachers need to design tasks that will enable learners to gradually develop new scientific concepts and make connections between ‘old’ and ‘new’ knowledge (Section 2.3.1).

Another aspect of the two textbooks is that they do not seem to cater for learners in terms of their socio-economic background (see Section 2.5.1). The examples given, such as apples, oranges, and lemons, are not accessible to some learners. Most of the everyday resources referred to in the textbook, are what Rennie (2011) terms the canonical science content of the traditional curriculum; that is, the examples used are typical of Western science and out of learners’ reach out of school. This appears problematic in term of the reasonable view that if “students are to operate as informed citizens in a world that is becoming increasingly global, then the science curriculum they experience at school must be sufficiently meaningful and relevant for them to perceive links with what they experience outside the school doors” (Rennie, 2011, p. 15).

For instance, learners might have different views and experiences when it comes to acids and bases, but these experiences are not taken into consideration. The onus is therefore on teachers to take cognizance of this and incorporate it into their teaching and learning repertoires. Also, teachers need to be able to go beyond what the textbooks say in order to assist learners to make links between what they know and the textbook knowledge.

Beard and Wilson (2006, p. 21) underline this by saying that “experience is meaningful engagement with the environment in which we use our previous knowledge to bring new meanings to interactions.” Therefore, if learners are not given opportunities to explore their own knowledge and depend only on textbook knowledge, then their cognitive development and conceptual understanding might be superficial.

Aikenhead (2006) comprehensively reviewed research on the outcomes of the traditional science curriculum and noted that the prevalence of a boundary between science in school and science in the community. Rennie (2011, p. 18) agrees, asserting that “students arrive at school each day informed by their experiences in the community but generally are expected to set aside knowledge from those experiences and, while at school, work with school-based disciplinary science knowledge and understandings that often seem quite narrow and disparate to their own experiences”. As a result, we see the creation of a boundary between the disciplinary science knowledge needed in school and the functional science knowledge used in the community.

Aikenhead (2006, p. 29) further argues that “most often canonical science is not directly useable in science-related everyday situations.” Hence, it is a good idea for teachers to supplement textbook knowledge and develop their own learning and teaching support materials (LTSMs), as it is proposed by Czerniewicz, Murray and Probyn (2000). Furthermore, such LTSMs should be accessible and relevant to learners’ everyday life experiences (Stears, Malcolm & Kowlas, 2003).

The two textbooks that I analyzed do not guide teachers on how to teach acids and bases nor do they provide teachers with teaching strategies. For this reason, it is of utmost importance for teachers to design their own lesson plans and units of work or modules in which they take into consideration learners’ prior everyday knowledge and experiences. Certainly, this would help learners to make sense of science in their everyday lives (Aikenhead, 2006).

This resonates with Rennie’s (2011, p. 17) argument that the science that happens outside school differs from the science that is learned at school. Rennie maintains that this occurs because the science concepts learned at school are idealized and simplified, stripped of all the associated and confounding variables that operate in the world outside of the textbook.

The national syllabus and policy documents are also not clear on how teachers should present this topic. For example, learners should be able to know, identify and name examples of acids

and bases in everyday life, and discuss acids that are common in foods, particularly fruits and others that have a sour taste (see Section 4.2.1). The examples mentioned include lemons, green apples, oranges and other commercialized fruits that are not necessarily available to learners in the rural areas.

6.3.2 Data from brainstorming sessions: Eliciting and mobilizing learners' prior everyday knowledge

Analytical Statement 2: Learners do not know that local everyday substances (e.g. fruits) are acids or bases.

The reason for the brainstorming sessions was to elicit and mobilize learners' prior everyday knowledge and experiences on acids and bases (Section 4.3). As mentioned in Chapter 4, it emerged that learners were not familiar with what acids or bases were. However, after giving them the hint, in an endeavour to scaffold their learning (Vygotsky, 1978), that anything that has a sour taste or anything that can be used for cleaning qualified as one or the other, learners were able to give me examples with which they were familiar. Here are the examples that learners gave:

- *Ombeke (a very sour wild berry which is red-yellowish in colour when ripens) (sourplum)*
- *Onkenkete (a local fruits known to be eaten by San people. It is also sour whether ripen or not) (buffalo thorn fruits)*
- *Oombu (a local fruit brownish in colour, a very delicious fruit for cattle herders, especially young boys)*
- *Ontantahe (wild berries also known to the food of san people)*
- *Ooshe (wild berries also delicacies of young boys when herding the cattle)*
- *Oonkwiyu (fruits from Fig tree) (cluster figs)*

From this list, I concluded that learners were not familiar with the conventional or canonical (Aikenhead, 2006; Rennie, 2011) examples of acids. It was then up to me to help them connect what they knew to the textbook knowledge.

In their study conducted in Nigerian schools, Oloruntegbe and Ikpe (2011) argue that some teachers do not encourage learners to connect their daily activities with classroom science and that it was difficult for learners to develop scientific concepts without the help of their everyday life experiences. Similarly, in her research conducted in South Africa, Kuhlana

(2011) found out that learners' prior everyday knowledge and experiences were hardly taken into consideration by teachers during teaching and learning. Yet learners, despite their different socio-economic backgrounds had, in one way or another, some form of prior everyday knowledge which could be tapped into during teaching and learning.

Furthermore, apart from the fruits they named being edible, learners pointed out that they could also be used to make *ombike* (a traditional Oshiwambo alcoholic beverage). When one was drunk from it and got caught for drinking and driving, they added, the breathalyser would not notice that the person was drunk, though it could be noticed by just looking at the person!

The same trend occurred when it came to bases. Learners were quiet until I gave them a hint regarding how we used bases at home. Learners then told me of the substances they used at home for cleaning purposes. However, it was clear to me that it was the very first time that they had heard the terms acids and bases. In their list of basic substances (see Section 4.3), there was no mention of any conventional bases.

Roschelle (1997) asserts that teachers should remember that learning depends on social interactions. That is, conversations shape the form and content of the concepts that learners construct. Only part of the specialized knowledge can exist explicitly as information, the rest must come from engagement in the discursive practices of the community (Roschelle, 1995, p. 5). Davis and Linn (2000) also stress that the teaching and learning of science should make science accessible, and models that make sense to the learners should be identified so that new information could be connected to learners' prior everyday knowledge. To be able to do this, science teaching should interact with the knowledge that learners bring to a given teaching situation (Leach & Scott, 2003).

But how can science teachers be empowered to do this? I agree with Rennie's (2011) argument that scientists and teachers need to work together on a regular basis, in ways that could enable students to experience "real-world" science, while teachers should stay in touch with contemporary science outside of school (p. 14). I am in support with the literatures that argue that, teaching a science curriculum that includes interaction with significant science-related issues beyond the classroom, demands that teachers work in interdisciplinary ways and integrate at least some parts of the curriculum. However, curriculum integration is neither well understood nor well accepted in science education (Rennie, 2011).

For example, towards the end of the brainstorming session, one learner stood up and said, “Sir, it’s like I met a word in mathematics which is a base, is it the same base or what?” (Section 4.3, excerpt 4). And there I was, instead of giving learners the opportunity to explore the integration of science with other subject content, just explaining it myself.

I also think that I used the recipe approach here, as criticized by Hodson (1990). Learners did not learn much in this situation. On reflection, I should have given my learners an opportunity to explain to each other what a base in mathematics meant, and only if they had difficulty should I have intervened.

Nevertheless, my study tried to close the gap between the everyday life experiences of learners and classroom science, as recommended by Rennie (2011). Rennie (2011, p. 21) argues that “more students can be given opportunities if their experiences of science in school and science in the community are brought much closer together by using community resources to explore science related issues that have local relevance, thus blurring the boundary between school and community”. However, she cautions that making effective use of community resources requires a considerable investment of time and effort.

In this study, the data revealed that learners had their own understanding and notions of what ‘acids and bases’ were, and did not know that fruit and other stems and substances familiar to them from their daily lives could constitute conventional science knowledge. And thus serve as what Bourdieu (2008) refers to as cultural capital. For this reason, Leach and Scott (2003) emphasize the importance of science teaching that starts from what the learners know and bring to a given phenomenon.

In the next section, I look at how the integration of learners’ prior everyday knowledge has enabled or constrained the grade 9 learners in their learning of acids and bases.

6.4 Observation of practical activities by a critical friend

Analytical Statement 3: Learner engagements in practical activities enable or constrain co-construction of knowledge and meaningful learning.

After the elicitation and mobilization of learners’ prior everyday knowledge, I tried to integrate their prior everyday knowledge and experiences into practical activities using easily accessible local materials. I wanted learners to construct their own learning and link it to classroom science. Jarvis, et al. (2003, p. 56) argue that learners can actively construct their own experiences either from home or their surroundings. In this case, learners were involved

in practical activities in which they were testing acidity and alkalinity in their local fruits and other substances that they themselves had brought to class. That is, I endeavoured to ensure that learners took responsibility for their learning, as is emphasized in constructivism (Section 2.5).

Various teaching strategies were combined to promote learners' engagement and participation. Learners were asked to mention locally available substances that contained acids or bases, based on their sourness or bitterness. The class shared local resources that they brought to class. I also brought in some conventional science chemicals that I borrowed from a neighbouring school since our school does not have a science laboratory, equipment and chemicals.

I divided the learners into groups and gave them instructions to carry out the activities. It has been noted that group activities are time consuming but when group members work together, learning results (Euvrard & Wilmot, 2000). Sisovic and Bojovic (2000, p. 263) confirm that cooperative learning is one of approaches that enables the active construction of knowledge, as well as the development of various skills.

It helped me as a teacher to observe how each learner performed and participated in the lessons. In the first activity (Section 4.4, excerpt 5), I wanted to make learners aware that the sourness in fruits is caused by the acids contained in them. I was trying to make a link between learners' prior everyday knowledge and conventional science. To do that I had to refer them to the textbook. To test for acids we use various indicators (see excerpt 5, Section 4.4).

The practical activities enabled learners to understand some concepts regarding acids and bases. Learners could still not believe that their own local *ombeke* (see Analytical Statement 2) could actually turn blue litmus paper red. I also found out that there was a lack of prior scientific knowledge in my learners. For example, when they were reporting their findings most of them could not use correct scientific terms. Instead of saying that acids reacted with zinc and gas was released or evolved, learners said; "*acids make zinc to boil and I saw smoke coming out of the test tube*".

Thus, I had to help them use the correct concepts or terms (Vygotsky, 1978; Hodson & Hodson, 1998). Vygotsky (1978, p.190) states that, "cognitive development results from a dialectical process whereby a child learns through problem-solving experiences shared with

someone else, usually a parent or teacher but sometimes a sibling or peer”. Initially, the person interacting with a child assumes most of the responsibility for guiding the problem solving, but gradually transfers the requisite skills to the child.

Vygotsky (1978) further asserts that, with appropriate adult help, children can often perform tasks that they are incapable of completing on their own. With this in mind, scaffolding, where the adult continually adjusts the level of his or her help in response to the child’s level of performance, is an effective form of teaching. Scaffolding not only produces immediate results, but also reinforces the skills necessary for independent problem solving in the future.

Vygotsky (1978, p. 86) refers to elastic space as the Zone of Proximal Development (ZPD), which defines it as “the distance between the actual developmental 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.” Vygotsky’s (1978, p. 86) emphasis is “what the child is able to do in collaboration today he will be able to do independently tomorrow”. My scaffolding of the learners was informed by this notion of the ZPD.

Overall, the practical activities captured the learners’ attention and stimulated them to want to find out what would happen next. It could be argued that learners were able to make sense of the subject content knowledge they were learning. This helps the teacher to explain more, as learners were asking question such as ‘how’ and ‘why’. It also gave an opportunity for learners to debate and argue, hence acquiring more skills and knowledge (Lemke, 2001).

Research and practice in chemistry education have provided evidence of the positive influence of cooperative learning and interaction with peers on cognition and the development of thinking (Johnstone, 2010; Wright, 1996; Sisovic & Bojovic, 2000). Learning in a group enables the exchange of knowledge and ideas among learners who may differ in their developmental levels and prior knowledge; that is, it stimulates learners to participate actively in the process of learning because it ensures social-cognitive conflicts due to different views, ideas and personalities (Sisovic & Bojovic, 2000, p. 264).

Through the practical activities, learners constructed their own meanings and were encouraged to think critically by my thought-provoking questions. Learners learnt from each other by sharing ideas, hence getting exposed to new concepts that enriched their understanding.

6.5 Mediation of learning

Analytical Statement 4: Learners' participation and engagement.

During my lessons, the critical friend observed that I walked about to give assistance to the various groups and supply further explanation where learners did not understand (Sisovic & Bojovic, 2000). This practice appears to be in line with how Sisovic and Bojovic (2000, p. 263) characterize the creation of knowledge: “instead of transmitting the knowledge in its final shape, it gets formed in the process of learner-teacher, learner-learner and learner-teaching content interaction”. Thus, the use of group work supports learner-centered approaches, provided that the activities are properly planned (Section 2.3.3).

Working in groups made it easier for the learners to help each other when answering questions. Roschelle (1997, p. 16) asserts that teachers' greater knowledge and skills enable them to assist learners in applying familiar knowledge in unfamiliar contexts and employing unfamiliar knowledge in familiar contexts. The learners were helped to make meanings and links between concepts (rather than being left alone to carry out practical activities while the teacher sits in front or at the back doing something else under the pretention of being a facilitator) (Leach & Scott, 1995).

Thus in this study, the active construction of knowledge through social interaction and interaction with the learning content helped my learners to develop cognition and understanding (Sisovic & Bojovic, 2000). The teacher who observed my lessons found that the questions asked to find out more about the learners' prior everyday knowledge were useful. Learners were also given a short summary on the chalkboard.

Analytical Statement 5: Integrating learners' prior everyday knowledge and experiences with practical activities enable or constrain learners' understanding of scientific concepts on acids or bases and learners' engagement.

The concepts involved in this study were, among others, acids, bases, neutralization and acid-metal reactions, as well as indicators. Learners had to classify substances using their properties. Since I was using local fruits as acids, I was worried that the reaction of acids with metals would not work well. Thus, I brought in some conventional acids such as hydrochloric acid. One of the weaknesses that I noticed was that I did not try to react the *oombu* and *oombeke* with any metal, so that learners could see what would happen.

By then most learners knew substances that were acidic and basic, so I asked them to identify the properties of acids, the use of indicators and the products of neutralization. Similar to Kuhlana's (2011) study conducted in South Africa on acids and bases, my assumption about the best way to teach the above concepts was to involve learners in practical activities using everyday materials (Section 4.3).

I agree with Roschelle (1997) who argues that prior knowledge forces a theoretical shift to viewing learning as conceptual change. Thus, in my study learners were afforded an opportunity to manipulate easily accessible resources in order to understand concepts (from known to unknown), which again resonates with Kuhlana's (2011) study.

Johnstone (2010, p. 25) in his model suggests that, "we should begin where learners are with their interests and experiences, and lead them to discovering new ideas among the familiar." It is for this reason that in this study, learners had to observe, think critically and compare the everyday substances they brought in with the conventional substances that I brought in, in terms of properties and how they were changing, for example, the litmus paper.

Furthermore, the practical activities were 'hands on', 'minds on' and 'words-on' in nature, as proposed by Maselwa and Ngcoza (2003) in their study. This was helpful in prompting learners' thinking about the world in which they live; especially about the things they use at home (Woodley, 2009; Kuhlana, 2011; Oloruntegbe & Ikpe, 2011).

Millar (2004) argues that real effective practical activities enable learners to bridge the gap between what they can see and handle and scientific ideas that account for their observations. The use of everyday materials in this study helped learners to feel more comfortable and good that their own 'cultural knowledge' could be used in school science and incorporated into the scientific discourse. Bourdieu (1998, p. 241) says that cultural capital can be acquired, to a certain extent, in the absence of any deliberate inculcation. Bourdieu (1998) further asserts that cultural capital always remains marked by its earliest conditions of acquisition, which through the more or less visible marks they leave help to determine its distinctive value. Furthermore, learners had the opportunity to ask questions (Section 4.2 & 4.3) and debate some of the things they observed during the practical activities.

Learners also had the opportunity to make predictions and arguments. For instance, in the practical lesson, learners argued that *ombeke* only turned the blue litmus paper red because the fruit is naturally red in colour when ripened (one of the acidic fruits they brought in). I

then asked them to use *ombu* (this fruit is brownish when ripened) to prove that the blue litmus paper could be changed to red by any local fruit.

Throughout the discussion I asked learners to predict what would happen if they squeezed fluids from *ombeke* onto blue litmus paper. Learners were convinced that the blue litmus paper would change to red, not because of the acidity in the *ombeke*, but because the *ombeke* itself was already red. To convince my learners, I gave them a phenolphthalein indicator and asked the learners to squeeze some fluids into the phenolphthalein solution. I drew their attention to the textbook that the indicator remained colourless in acids. I concur with Maselwa and Ngcoza (2003) that the Predict-Explain-Explore-Observe-Explain (PEEOE) approach can help learners to give explanations for their actions. In the next paragraphs I discuss the test results.

According to the Curriculum (2010) assessment guidelines for Physical Sciences, tests could be used for both summative and formative purposes. In this study, I gave my learners a test for formative assessment purposes (Section 4.4.2). The test was in two sections: the first part was about recalling information and the second part was based on application, where learners were required to define concepts and give examples. By giving this test, I wanted to find out how much learners had learnt from my teaching and what understanding they had of acids and bases after the whole process. From the test (Section 4.4.2), I found out that there were still some misconceptions to be dispelled, such as, ‘*smoke coming out*’ instead of ‘gas evolved or released’, and a definition of acids as ‘*something that could make one to be thin when drank*’.

An important aspect worth mentioning is that learners could not link their prior everyday knowledge to the ‘conventional’ examples of acids and bases. Also, some learners could not understand that acidity was caused by the concentration of hydrogen ions in the solution. Perhaps, I did not explain these concepts very well to the learners. Given another opportunity I would go deeper into explanation of the concentration of acids and bases.

6.6 Stimulated recall discussion and focus group interviews

Analytical Statement 6: Enhancement of learner talk and argumentation during science lesson.

During the stimulated recall discussion with my critical friend, strengths and weaknesses of the study were highlighted. It was noted that I should have worked with smaller groups so that each learner could have had a chance to feel the apparatus and chemicals during the

practical activities (Section 4.5). Group size could be as small as two members to as large as 5 members. Goosen and Mentz (2009, p. 67) agree that the benefits of cooperative learning are enhanced when group size does not exceed four members, as the possibility of free riding increases significantly with each additional member added to the group. Asking questions of groups instead of individual learners was another excellent suggestion, and it led me to assume that all learners felt included in the lesson.

I noticed that my critical friend tended to equate all prior everyday knowledge to indigenous knowledge and believed that it resulted in learning (Kibirige & Van Rooyen, 2006). Kibirige and Van Rooyen (2006, p. 67) assert that if we consider the term curriculum in the wider, more embracing sense, then curriculum encompasses experiences both inside and outside the classroom. However, they caution that the absence of indigenous knowledge (IK) in science curricula has significant consequences for some learners, to the extent that they experience conflict between their existing knowledge and the knowledge of the school science curricula. However, romanticizing IK might cause learners to fail to make a proper link between the two bodies of knowledge.

The focus group interviews revealed that learners had fun during the practical activities and were for instance amazed by the colour changes of litmus paper and phenolphthalein when acids or bases were added. In this way they acquired an understanding of the properties of acids and bases from their prior everyday knowledge and using easily accessible materials. It seemed clear that using learners' prior everyday knowledge as a starting point for the exploration of scientific concepts and inquiry procedures served to enhance learning. However, I had to take care to make the link with more conventional textbook science and dispel any misconceptions that their IK had engendered.

During interviews and during the lessons, I had to code-switch, as learners' proficiency in English was inadequate and they preferred to express themselves in their mother tongue (Oshiwambo). Learners' excessive use of hand gestures when making a point or clarifying something, and the use of Oshiwambo when writing (Section 4.3) were signs of learners' lack of fluency in English, which is the official Medium of Instruction (MoI) at my school and in Namibian public schools generally.

Similar to Kuhlane's (2011) study, my study was not investigating the language problem encountered by learners during science lessons *per se*, but since such related problems came up, I think this could be an area worth researching in the future. I also noticed that learners

had spelling problems and very often confused daily language with scientific terms (Section 6.6 above). And some learners thought that the salt produced by neutralization was always table salt.

Therefore, it is important to consider different approaches that could be used to help learners not to confuse everyday language with scientific language. It could be argued that teachers need to find ways to minimize language problems in their science classroom, though this was beyond the scope of this study.

6.7 Concluding remarks

This chapter provided interpretation and discussion of the data presented in Chapter 4, using some of the literature reviewed in Chapter 2. Acids and bases fall under environmental chemistry in our national syllabus and comprise the topic used to introduce chemistry in the Junior Secondary Phase. Surprisingly enough, it emerged from the documents analysed that acids and bases are not taught in grade 8, despite the fact that acids and bases are a starting point of this phase (grades 8-10). The themes that emerged were discussed in relation to the analytical statements that were informed by my research questions.

In the next chapter, I formulate conclusions, make recommendations, and discuss the limitations of my research study.

CHAPTER SEVEN

DISCUSSIONS, RECOMMENDATIONS AND CONCLUSIONS

First, designers should seek to refine prior knowledge, and not attempt to replace learners' understanding with their own. Second, designers must anticipate a long-term learning process, of which the short term experiences will form an incremental part. Third, designers must remember that learning depends on social interaction; conversations shape the form and content of the concepts that learners construct (Roschelle, 1995, p. 5)

7.1 Introduction

This study has explored learners' prior everyday knowledge and experiences, and how these can be used during the teaching and learning of concepts in chemistry, in particular, that of acids and bases. The study was specifically aimed at investigating whether integrating learners' prior everyday knowledge and experiences with practical activities enabled or constrained meaning making, conceptual development and the understanding of acids and bases.

This chapter presents a summary of my research findings, as well as coverage of limitations, recommendations and conclusions.

7.2 Discussion

The analysis of the two physical Science textbooks and the Syllabus contents on acids and bases revealed that there is a link between the three documents. The essential difference between them lies in how the content is to be presented to the learners, considering their prior everyday knowledge. For example, the examples used in the two textbooks do not cater for all learners. Thus, teachers need to be able to go beyond what the textbooks say in order to assist learners to fully understand the syllabus content. According to Beard and Wilson (2006, p. 21), experience is meaningful engagement with the environment in which we use our previous knowledge to bring new meanings to interactions. If learners are not given opportunities to explore their existing knowledge, depending solely on textbooks might confuse their understanding of the subject at hand. It is therefore a good idea for teachers to supplement textbooks and develop their own teaching and learning support materials

(LTSMs) (Czerniewicz, Murray & Probyn, 2000). It should be ensured, however, that such LTSMs are relevant to learners' everyday life experience, as proposed by Stears, Malcolm and Kowlas (2003).

In this case study, I attempted to elicit learners' prior everyday knowledge and experiences regarding acids and bases with the intention of incorporating these experiences into 'hands-on', 'minds-on' and 'words-on' practical activities (Maselwa & Ngcoza, 2003), so as to promote meaning making, conceptual understanding and development. It emerged from this study that the actual process of eliciting learners prior everyday knowledge and experiences was something of a challenge, time consuming and requiring thorough preparation.

This suggests, by and large, that the elicitation of learners' prior everyday knowledge and experiences is easier said than done. Notwithstanding, Roschelle (1995, p. 1) suggests that if learners' prior knowledge is neglected, the learners can miss the educator's intentions or the educator could miss what to add to what the learners already know. Roschelle further points out that in many instances teachers tend to focus only on the aspects that they want their learners to learn.

During the focus group interviews with the learners, I found myself in a teaching mode rather than a research mode. I scaffolded and praised my learners for satisfactory responses and in a way censured certain responses. I had to use Oshiwambo to make sure learners thoroughly understood the questions, even though the medium of instruction (MoI) is English. This is supported by a research by Probyn (2009, p. 123) which asserts that "where teachers and learners share a common home language, there is frequently a gap between language policy and practice, and code switching by teachers and learners is a common strategy to achieve a range of social and pedagogical goals." This resonates with what Woolnough, MacLaughlin and Jackson (1999, p. 28) says that "the beauty of teachers doing research with their own pupils is that they control the teaching, and vary it according to what they want to investigate in such a way that it is always in line with the objectives of the teaching program."

From the stimulated recall discussion, it emerged that the use of worksheets in my teaching and learning was successful in promoting group discussion and active participation by groups of learners. Also, learners were able to identify some concepts and thus, to a certain extent, conceptual development on acids and bases was promoted. I believe that the worksheets helped incorporate learners' prior everyday knowledge and experiences into 'hands-on', 'minds-on' and 'words-on' practical activities, as proposed by Maselwa and Ngcoza (2003).

However, although the worksheets encouraged learners to make predictions during the practical activities (Maselwa & Ngcoza, 2003), I found them somewhat prescriptive, in the way that has been criticized by Hodson (1990). This is an area I would like to improve on in future.

Nonetheless, my research questions were satisfactorily answered. A strong finding running through the responses of my critical friend and learners is that there was active participation and excellent engagement in the lessons. The critical friend indicated that learners' concentration was also good, exceeding her expectations given the type of learners we have at school. She attributed this to learners wanting to take part in practical activities using the materials they brought to class. Overall, there is strong evidence to suggest that eliciting and mobilizing learners' prior everyday knowledge and experiences and incorporating it into practical activities enables learner engagement and meaningful learning.

In terms of meaning making and collaboration, learners greatly appreciated that they were able to share knowledge and ideas when they worked in groups. They testified that they were able to point out each other's mistakes and thus learned from one another. The data also revealed that learners who normally feared to ask assistance from the teacher now had an opportunity to ask for help from other learners and thus received assistance.

Learners were impressed by witnessing the reaction between acids and metals, phenolphthalein changing colours in bases, and when the red colour of *ombeke* (sourplum) disappeared when added to the phenolphthalein indicator. Thus, the integration of learners' prior everyday knowledge and experiences with practical activities enabled meaning-making and an understanding of acids and bases. However, it appears that conceptual development lagged behind somewhat. Some learners were still failing to make a link between conventional textbook science and their prior everyday knowledge and experiences. Rennie (2011) proposes that there is a need for teachers actively to blur this boundary.

7.3 Limitations of the study

My study is located within an interpretive paradigm, which means that its findings cannot be generalized. More specifically:

- My study was unable to investigate the concepts such as 'concentration of substances' and 'alkalinity', which limited further understanding and development of new knowledge. Perhaps the learners' problem in linking their prior everyday knowledge

to conventional science could be due to having had no such experience previously. For instance, learners were struggling to understand that in the fruit *ombeke*, a certain quantity of hydrogen ions is responsible for its acidity;

- It also became apparent that focus group interviews do not necessarily create a relaxed atmosphere as anticipated, in which learners feel free to talk. During the interviews some learners were passive whereas others dominated. Some learners seemed to be afraid of giving responses that they thought would be regarded as undesirable by me;
- Another key factor in the passivity of learners was language proficiency. For example, during the brainstorming sessions, practical activities sessions and focus group interviews, I had to translate almost all the questions into Oshiwambo for learners to respond. The language issue remains a problem when learners are second language speakers of the medium of instruction (MoI).
- Time also did not allow me to find out the scientific names of the local fruits that learners brought to class. It would have been useful for readers to know the scientific names rather than just the popular ones.

7.4 Recommendations

The findings of my study reveal that consideration of learners' prior everyday knowledge helps them to understand the subject at hand, though incorporation of this knowledge was found to be easier said than done. In the light of my findings, I recommend the following:

- Programmes that deal with teachers' professional development should recognize the importance of prior everyday knowledge and of its incorporation in teaching and learning;
- These programmes should encourage teachers to be researchers so that in the process they acquire research skills in order to improve their practice;
- From the document analysis, I found out that acids and bases are not taught at the entry level of junior secondary phase, that is, grade 8. Instead, it only starts in grade 9, and yet the topic is an important foundation for chemistry. Curriculum and policy makers should therefore consider revisiting the Junior Secondary Certificate (JSC)

Physical Science curriculum, to provide for acids and being taught from grade 8 and recurring throughout the whole junior secondary phase;

- Learners should be encouraged to ask questions, to be involved in discussion and debate so as to improve their language proficiency in the science classroom and in general. This could be done in conjunction with practical activities, working in pairs or individual presentations in class. This might improve learners' confidence and increase participation during science lessons;
- In my future research, the design of my teaching and learning unit will need improvement to promote enquiry and investigative skills;
- I also recommend the use of concept maps in which learners could show the links between concepts; and
- Teachers need to be 'trained' on how to use English as a second language and as a mediational tool during science lessons.

In a nutshell, more research or investigation based on acidic and basic substances should have been given to the learners to extend their prior everyday knowledge. That is, examples of insects with acidic and basic fluids such as wasps and bees could have been explored. I also feel that I should have encouraged my learners to come up with their own indicators, such as red cabbage and extract from petals of flowers, in juxtaposition with the conventional science indicators, just to make it clear that science is around us.

Science has often been perceived as being difficult to learn owing to its nature and the methods by which it is usually taught. In fact, according to Taylor and Bogdan (1998), it is usually taught without any effort to understand the learners and the nature of subject being taught. It is against these backdrops that in this study an attempt was made to understand how learners use their existing prior everyday knowledge to construct meaning making and develop conceptual understanding during the teaching of acids and bases in grade 9.

7.5 Areas for future research

This case study forms a useful platform for future research in the following areas:

- Study of the influence of learners' prior everyday knowledge and experiences in other, different science topics. This study could be done simultaneously with an

investigation into teachers' prior everyday knowledge and experiences in such topics as well;

- To establish teachers' attitudes towards practical activities using local materials that learners are familiar with; and
- A study on learners' and teachers' language proficiency so as to improve communication during teaching and learning.

7.6 Reflections

7.6.1 An overview of my study

As stated in Chapter 1, the main goal of this study was to investigate whether integrating learners' prior everyday knowledge and experiences with practical activities when teaching acids and bases in grade 9 enabled or constrained meaning-making, conceptual development and understanding. This was explored by adapting a qualitative case study approach. The following questions helped to keep focus in my study:

- What prior everyday knowledge and experiences related to acids and bases do grade 9 learners bring to the science classroom?
- Does elicitation and mobilization of learners' prior everyday knowledge and experiences on acids and bases enable or constrain learner engagement?
- Does learner engagement enable or constrain meaningful learning?
- Does integrating learners' prior everyday knowledge and experiences with practical activities enable or constraint meaning-making, conceptual development and understanding of acids and bases?

These questions were mainly answered by the use of brainstorming and discussion sessions. The sessions were observed and also videotaped for a review with my critical friend. I also depended mostly on evidence from audio and video transcripts and observation schedule by a critical friend. For example, the stimulated recall interview with the critical friend who observed me and the focus group discussion with the learners. I also looked at the critical friend's reflections and the learners' worksheets which they had to complete during the practical activities.

These techniques have illuminated learners' understanding of acids and bases, how they are used and what they are used for. Everyday examples of acids and bases have also helped learners to differentiate and classify acids and bases characteristics. Stears, Malcolm and Kowlas (2003) in their study revealed that the use of everyday knowledge in the science classroom increases the level of learners' engagement and that learners enjoy making links between their different experiences when curriculum is designed to facilitate such links.

Furthermore, the use of everyday knowledge and experiences as well as materials during practical activities encouraged learners to ask questions and hence to understand the concepts better. Overall, conducting practical activities using easily accessible materials proved to be quite a feat, however learners liked it so much as their local fruits were brought into the learning environment.

7.6.2 My own experience of practical activities at school

I attended a public school in a formerly disadvantaged area in a village called Oshikuku, north of Oshakati town. Although it was a big school, we had only one teacher responsible for all classes, grade 8 to 12. Due to the time factor, that faced our teacher, which I only understood when I went to the University of Zimbabwe, he was unable to do any practical activities. Teachers' demonstrations were done for those learners who were doing extended syllabus, of which I was one of them. However, we never did group or individual practical activities. As a result, I went to tertiary institution without even knowing how to handle or use a burette, pipette and so forth.

I do, however, feel that practical activities are necessary as the Chinese saying goes *“I hear, I forget, I see I remember, I do and I remember and understand”*. Therefore the learners under current education system are fortunate in this respect, as practical activities are foregrounded in the syllabus. The first goal of the current Namibia Senior Secondary Certificate (NSSC) science syllabus is to “provide, through well designed studies of experimental and practical science activities, a worthwhile educational experience for all learners” (Ministry of education, 2010, p. 2).

However, I think that as a teacher I need to be very careful that I do not fall into the ‘recipe – following’ trap, and that the most importantly I need to convey to my learners during practical work are the concepts behind the experimental work. Also, I think that it is important to inform and let the learners understand right from the beginning that not all experiments will work out as we hope they will, in fact they most probably will not work.

Therefore, suggestions that I would make in order to create a better learning experiences for the learners are that, “teacher submits to him/herself that effective science teaching is not necessarily embedded alone in practical activities” (Farmery, 2002, p. 87). However, things such as clear outcomes (which are conveyed to the learners), clear instructions and explanations, thought-provoking questions that lead to learners asking good questions, recapping of previous knowledge, learners’ responses should be valued and good feedback is essential. I also believe that a science class and its teacher should consider learners’ prior everyday knowledge and experiences when carrying out practical activities.

7.6.3 My research experience

When I was told that my research proposal had received the go ahead from the Education Higher Degrees Committee (EHDC), I was ecstatic. Little did I know how much more work lay ahead of me than I had anticipated. During the course of B Ed honours, my supervisors asked us to conduct a pilot research for our topics. This exercise was worthwhile and paid dividend. However, eliciting prior knowledge during the actual study was challenging. I would like to reiterate that the process is easier said than done. However, I do not by any means imply that the exercise is impossible, but I think that it needs careful planning and conducting during the lesson. One should decide whether it would be a once off event or a continuous process that takes place in stages as the lesson progresses.

The writing of the thesis was mind-boggling and tiresome. At times I wanted to throw in a towel. The writing of the literature review and data analysis will remain indelible in my mind. A lot of readings had to be done before I could get a better understanding of the learning theories, let alone making critical analysis of such theories. I really enjoyed collecting mountains of data, but it gave me sleepless nights. I found it challenging to write a synchronized analysis from different data-gathering tools. After more consultation with my supervisors and more readings, there was light at the end of the tunnel and indeed not an oncoming train. The request by the circuit office that I should help with the grade 10 continuous assessment (CASS) moderation made things worse, not to mention my own revision programme at school with my classes, especially the grade 10s.

Nonetheless, doing the research has helped me to be patient with whatever I do and to have good listening skills. My writing skills have also improved and are still improving. The research process has also allowed me to be critical about my practices and the way I do things in my class. Before I undertook the research, I used to teach for examinations purposes and

just to finish the syllabus without realizing that there is more to teaching than just teaching learners for examinations. I was also one of those teachers that label learners as slow learners while I did not do anything to help them realise their full potential. I have thus taken this journey to be a life changing experience.

In summary, monitoring the practical activities using worksheets was enlightening. I feel I have a better understanding of the importance of engaging learners in various teaching and learning strategies and types of practical activities in order to promote conceptual understanding. I am now planning to use the same methods of incorporating learners' prior everyday knowledge and experiences into 'hands-on', 'minds-on' and 'words-on' practical activities with a view to enhance meaning making, conceptual understanding and development with other topics in my teaching and learning practices.

Given the findings of my study and the challenges I encountered in eliciting prior everyday knowledge and experiences from my learners and focus group interviews, the process and execution was exciting, an eye-opener and worthwhile.

The course work and this thesis have been equally enriching and educational. This journey has fulfilled my first step towards my dreams of playing a valuable role as a teacher and in the community and that I have become a critical and reflexive practitioner. From this study it is clear that there is more than what we take for granted as teachers when we work with our learners in the classrooms. The research skills acquired in this course made me view teaching and learning with a different set of lenses. How I wish that all teachers could go through the same process in Namibia.

7.7 Concluding remarks

In this chapter, discussion, research limitations, areas for future research recommendations and personal reflections were presented.

The study revealed that for researchers to be engaged in investigating prior everyday knowledge and experiences they need to be equipped with a variety of skills, such as questioning, probing, patience and scaffolding. Without these skills, superficial data might be obtained. This also suggests that teachers need to be knowledgeable in their subject content

knowledge and be mindful of the elicitation and incorporation of learners' prior everyday knowledge and experiences into their teaching and learning practices.

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APPENDICES

Appendix A: Letter to the Inspector of Education

28 May 2012

A

Linus Kambeyo
P. O. Box 7129
Oshakati, Namibia
Cell no: 0812788020

The Inspector of Education
Omuthiya Circuit
Oshikoto Region

Re: Permission to carry out my research with the grade 9 learners from O-Iipundi Secondary School, within the school premises

I, Linus Kambeyo, a Head of Department at Omuthiya-Iipundi Secondary School, hereby requesting a permission to carry out a research study at School. I wish to carry out the research study on the school premises with the Grade 9 learners. The principal has granted permission but the university requires me to obtain permission from his immediate supervisor.

I am doing a Master Degree in Science Education (part-time) with Rhodes University in South Africa Since 2011. This is a two-year course, which consist of Coursework in the first year and a thesis in the second year. I am in my final year (2012), where I am to carry out a research study. The research study entitled *'Exploring the benefits of integrating learners' prior everyday knowledge and experiences with practical activities on acids and bases with a view to enhance their conceptual development and understanding: A Namibian case study'*.

Research has found that teachers tend to teach without considering their learners' prior everyday knowledge. It is also argued that learners tend to consider their prior every day knowledge as something useless and backwards, because their prior every day knowledge is never mentioned during the teaching and learning. It is against those backdrops that I decided to embark on such a research with a view to help a Namibian child. I am also intending to carry out my research during Saturdays.

I am looking forward to hearing from you.

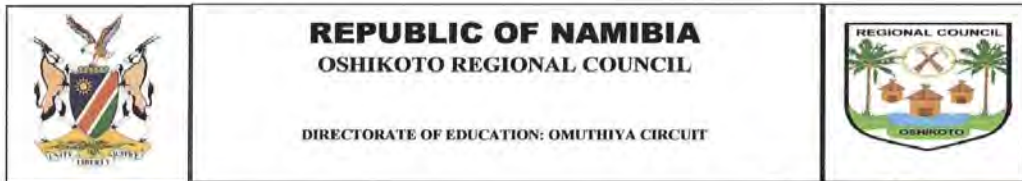
Yours sincerely,



Linus Kambeyo
HoD: Maths & Science O-Iipundi SS
Student # 09K6352



Appendix B: Reply from the Inspector of Education



Enquiries: F. Nangolo
Tel: (065) 244045
Cell: 0811498483
Ref: 9/4

Private Bag 2028
Ondangwa
June 07th, 2012

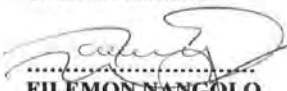
A

Dear Mr Kambeyo

RE: PERMISSION GRANTED TO CARRY OUT A RESEARCH

I am glad to inform you that you are granted a permission to carry out a research for the Rhodes University of your Master of Education in Physical Science. As per your communiqué, the research is to be carried out at your school, Omuthiya Iipundi Secondary School, with the Grade 9 D learners only.

Yours in Education


.....
FILEMON NANGOLO
INSPECTOR OF EDUCATION
OMUTHIYA CIRCUIT



Appendix C: Requisition letter to the Principal

Rhodes University
Linus Kambeyo
Student number 09K6352
Cell no: 0812788020
28-May- 2012

B

The principal
Omuthiya-Iipundi Secondary School
P .O BOX 19175
Omuthiya

Dear Sir

Re: Requisition for Permission to conduct a Research studies at the school

I the undersigned hereby humbly asking for permission to conduct a research study in the school. The research will be based on; *Exploring the benefit of incorporating the learners' prior-everyday knowledge and experiences with practical activities in the teaching of acids and bases to enhance conceptual understanding*. I will be doing my research with the grade 9 D learners.

This research study will hopefully improve my understanding of the potential of integrating learners' everyday knowledge and experiences in the teaching and learning of acids and bases, with an emphasis on using everyday materials familiar to learners. In addition, there is a potential for more or even new insights into the role of practical activities in the science class, to help in making the abstract prior-knowledge more concrete and clearer. The study might provide specific insights into the teaching of acids and bases and their related scientific concepts and processes and hence cast light on the motivational potential of everyday materials and activities to arouse learners' interest in science.

Furthermore, it is envisaged that this study would promote use of a variety teaching and learning support materials with textbooks used as references rather than as sole sources of knowledge.

Thank you very much for your understanding.

Yours truly,

.....
L. Kambeyo

Masters' Student: Rhodes University



Appendix D: Reply letter from the Principal



P. O. Box 19175 Omuthiya, Tel/Fax 065 244110 e-mail: omuthyaiipundiss@web.com.na
Enquiries: Gerhard Ndafenongo 0812313886 25th June 2012

Dear Mr. Kambayo

B

This letter serves to inform you that my office has no hesitation or whatsoever in granting you the opportunity in carrying your research at my school. As per our communiqué you are to carry out the research in Grade 9D in the subject Physical Science.

It should be noted however that, doing your research should not interfere in your day-to-day activities of the department.

Wishing you all the best in your endeavors.

Your sincerely

GERHARD NDAFENONGO
BETD (OCE), FDE (UNAM), B. ED-HONOURS (RHODES), M.ED (RHODES)
THE PRINCIPAL

All official correspondence should be addressed to the Principal

Appendix E: Letter to the parents

28-May-2012

Mr L. Kambeyo

Omuthiya/Iipundi Secondary School

Omuthiya

C
Omuvali omusimanekwa gwa

RE: Ekuthombinga lyomunona momapekeko

Omulongi goshilogwa shuunongononi (Physical science) posikola Omuthiya ota ka ninga omapekapeko kombinga yo (Acids and Bases) omolwa eilongo lye lye thaa tha

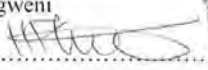
Omapekapeko nagka otaga ka ningilwa posikola pethimbo lyootundi nomoma lyomakaya galwe. Omulongi okwa pewa nale epitiko okuza kombelewa yoMutaleli shikandjo noko mbelewa yomukululuntusikola.

Omulongi ota indile nee epitikilo komuvali opo; A pitike; *Edhina lyomulongwa* akuthe ombinga momapekapeko ngaka. Omulongi okwa hala woo okutseyithila aavali kutya opena omathano nuuvideo tau ka thanekwa. Omauyebele taga ka monikwa oku za momapekapeko ngaka ita ka longithwa nande muuwinayi washa.

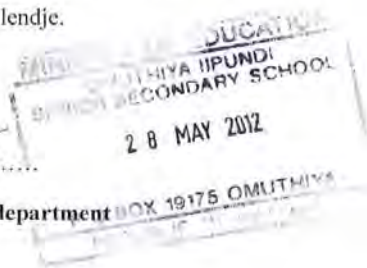
Udhitha okambapila kakwatelwako nde to ka tumu koskola

Tandi unene sho to shi ningilendje.

Neyelo gweni



Linus Kambeyo (Head of department)



Appendix F: Consent form

C

Edhina lyomuvali

Edhina lyomulongwa

.....

Gandja okangombe eto shaina

Eeno. Onda gandja epitikilo



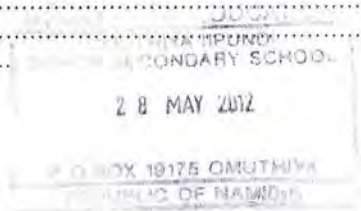
Eshaino:

Aawe, inandi gandja epitikilo

Eshaino.....

Etompelo kutya omolwashike ino gandja epitikilo

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



90

D.

Brainstorming schedule

1. How often do you wash dishes at your home?
 Two times I wash at ^{before} ~~when~~ I eat and not put food
 and I use to wash at when I'm finish to eat.
2. Mention the types of washing agents/materials used in your kitchen (cooking area)?
 Ash → You take ash and add water then it became a soap.
 Polioje, ngele, Ohunima, shajezeta, dewu, aka, jogilha, ashfimo.
3. What types of local fruits are you familiar with?
 Ondungo, Ashetele, Ongongo, combe
4. Describe the taste of different fruits you have eaten?
 Ondungo they ^{have} ~~are~~ sour tastes while combe and
 condungo ash ashetele they have sweet tastes.
5. In your own words, describe what do you, understand about acids and bases.
 An acid is any chemical that ^{have a sour tastes} ~~make you to vomit~~ vomit
 when you taste it e.g salt.
 Base is any chemical that ^{have} ~~are~~ a ^{bitter} ~~sweet~~ taste
 if you able to taste it e.g sugar, salt.
6. Describe the taste of acids and base.
 Acids
 is a substance that has a sour taste
 Bases are material that make something clean
7. Give examples of acids and bases that you are familiar with.
 base - ash and salt
 acid - Lemon and ~~vinegar~~ Vinegar

G.

15/20

~~WA~~

ACIDS and BASES 2: CHEMICAL REACTIONS

Name: _____

Date: 12/06/2012

Most acid solutions look like water. You can only be sure it is an acid by its chemical properties.

Experiments to investigate some chemical reactions with acids.

Experiment 1: The properties of acids.

Aim: To observe the properties of a laboratory acid (HCl) and a household acid (vinegar).

Method:

1. The test tubes are labelled 1 to 6. Add some hydrochloric acid (HCl) to test tubes 1 & 4, vinegar to test tubes 2 & 5 and water to test tubes 3 & 6.
2. Tear the blue litmus paper into 3 pieces. Test each liquid with the litmus paper.
3. Drop a piece of magnesium ribbon into the HCl in test tube 1. Watch what happens in the test tube; put a lighted splint into the mouth of the test tube; also feel the test tube.
4. Repeat step 3 with the vinegar in test tube 2, and the water in test tube 3.
5. Take a small amount of calcium carbonate on the tip of the spatula and add it to the HCl in test tube 4. Note any changes. Test the gas given off with a lighted splint.
6. Repeat step 5 with the vinegar in test tube 5 and water in test tube 6.

Results:

Table to show some of the reactions of acids

TEST SOLUTION	OBSERVATIONS		
	Blue Litmus Paper	Reaction with magnesium	Reaction with calcium carbonate
Hydrochloric acid	It turn Red ✓	Zinc produce some hydrogen gas and it react ✓	Magnesium dissolve in the acid ✓
Vinegar	It turn Red ✓	It produce smoger ✓	✗
Water	It does't change the colour ✓	Nothing has happen ✓	Nothing happen the carbon will dissolve in water

NOTE: Tests for gases: Carbon dioxide puts out a flame.
A flame in hydrogen gives a 'pop' sound
Oxygen lights up a glowing splint

Conclusions:

1. Dilute vinegar and hydrochloric acid are acids because they turn blue litmus red.
2. water is not an acid because the litmus did not change colour.
3. The reactions show that acids have these properties:
 - o Acids turn blue litmus paper to red ✓
 - o Acids react with magnesium (and many other metals) to produce hydrogen gas. ✓
 - o Dilute acids react with calcium carbonate to produce hydrogen, water and carbon dioxide gas. ✓

12/29/12

ACIDS and BASES 2: CHEMICAL REACTIONS

Name: _____ Date: 12/29/12

Most acid solutions look like water. You can only be sure it is an acid by its chemical properties.

Experiments to investigate some chemical reactions with acids.

Experiment 1: The properties of acids.

Aim: To observe the properties of a laboratory acid (HCl) and a household acid (vinegar).

Method:

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6. Repeat step 5 with the vinegar in test tube 5 and water in test tube 6.

Results:

Table to show some of the reactions of acids

TEST SOLUTION	OBSERVATIONS		
	Blue Litmus Paper	Reaction with magnesium/zinc	Reaction with calcium carbonate
Hydrochloric acid	It changes to red. ✓	It's started reacting. Zinc chloride has been produced. We can sometimes bring up hydrogen gas. ✓	The acid carbonate has gone into water and salt when acid went in. ✓
Vinegar	It turns red. ✓	It will react the same. ✓	The magnesium dissolved. ✓
Water	Nothing has changed. ✓	Nothing will happen. ✓	The carbonate will dissolve in water. ✓

NOTE: Tests for gases: Carbon dioxide puts out a flame.
 A flame in hydrogen gives a 'pop' sound
 Oxygen lights up a glowing splint

Conclusions:

1. Hydrochloric acid and ^{Vinegar} ~~magnesium~~ are acids because they turn blue litmus red.
2. ~~water~~ is not an acid because the litmus did not change colour.
3. The reactions show that acids have these properties:
 - o Acids turn blue litmus paper to red.
 - o Acids react with magnesium (and many other metals) to produce hydrogen gas.
 - o Dilute acids react with calcium carbonate to produce carbon dioxide gas.

7.

ACIDS & BASES & SALTS

Classifying Compounds

The **elements** are classified in the Periodic Table according to their properties. The **compounds** can be grouped by their properties but there is not only one classification. Two ways of classifying them are: acids, bases and salts
organic and inorganic compounds

Properties of Acids and Bases

ACIDS	BASES
<ul style="list-style-type: none"> ▪ Taste sour ▪ All dissolve in water- form a solution ▪ pH between 1 & 7 ▪ When acids dissolve in water they release hydrogen ions (H⁺) ▪ turn blue litmus red 	<ul style="list-style-type: none"> ▪ Taste bitter & feel soapy or slippery ▪ Only a few dissolve in water, called alkalis ▪ pH between 7 & 14 ▪ when bases dissolve in water they release hydroxide ions (OH⁻) ▪ turn red litmus blue

Strength and Concentration

Acids: The **strength** is related to how easily it releases hydrogen ions (H⁺)
 strongest acid: sulphuric acid
 ↓
 nitric acid & hydrochloric acid
 ↓
 carbonic acid & acetic acid
 weakest acid: sulphurous acid (H₂SO₃)

The **concentration** tells you how much of the acid is dissolved in a solution. This is usually given as the number of moles of substance in 1dm³.

Example: 1.0 M HCl contains 1 mole of HCl per dm³.
 1.0 M CH₃COOH contains 1 mole of CH₃COOH per dm³
but HCl is a stronger acid as nearly all of it is ionised to H⁺ and Cl⁻ ions in the solution.

Bases: The stronger a base is the more easily it releases OH⁻ ions
 strongest bases: sodium and potassium hydroxide
 ↓
 ammonia solution
 ↓
 calcium hydroxide
 weakest base: magnesium hydroxide

Like acids basic solutions of the same concentration can be different Strengths eg. sodium hydroxide is a stronger base than ammonia solution because it releases OH⁻ ions more easily when it dissolves in water.

Indicators

Indicators are used to find out if substances are acidic, basic or neutral (pH 7). To be sure you must see a **change in colour**. Many come from plants, some are synthetic.

Some commonly used indicators

Indicator	Initial colour	Colour in acid	Colour in base
Bromothymol blue	blue	Yellow	blue
Litmus paper	red or blue	red	blue
Methyl orange	orange	red	yellow
Phenolphthalein	colourless	colourless	pink
Red cabbage extract	blue	pink	green
Colour-changing lipstick	green	green	pink
Universal indicator	Is a mixture of different indicators so gives a range of colours. It can be used to find out the strength of acids or bases.		

Measuring strength - The pH Scale

The pH scale ranges from 1-14 (1-7 acidic, 7 neutral and 7-14 basic (see below))

The pH scale, colours with universal indicator & some common acids & bases

ACIDS					NEUTRAL				BASES				
Increasing strength									Increasing strength				
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Red	→	Orange	→	Yellow	→	Green	→	Dark green	→	Blue/green	→	Dark blue	
HCl	acid	vinegar		tomatoes		pure sea		baking		tooth-		cleaners	NaOH
	in		soda	rain		water		water		soda		paste	
	batteries		water	water						soap			

The pH of blood

Normal human blood has a pH of 7.35. Blood pH depends on many factors including the amount of CO₂ in the blood, what is eaten, health etc. The pH is strictly regulated by buffers (substances that can resist changes in pH when a strong acid or base is added) in the blood eg. haemoglobin, plasma proteins and H₂CO₃ (aqueous carbon dioxide). If the pH is altered the body suffers as O₂ delivery to the cells and mineral absorption are affected, and enzymes, organs and other processes cannot function normally.

Chemical Reactions with Acids and Bases

Neutralisation

Acids and bases are chemical opposites, they have the opposite effect on indicators eg. red and blue litmus paper. When you mix an acid and a base they react and cancel each other out. The new substances are not corrosive.

An acid and a base form a salt and water. Example: $\text{HCl} + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O}$

Bites and Stings

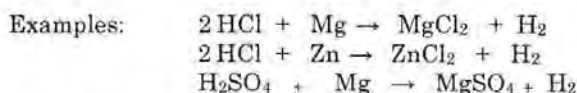
When an insect bites it injects a small amount of chemical into the skin. Bees inject an acid which can be treated with calamine lotion or baking soda which neutralise the acid. Wasps inject an alkali, which can be neutralised with a dilute acid eg. vinegar.

Making soluble salts

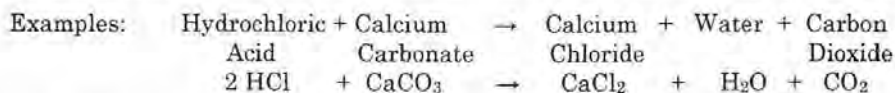
These reactions will make a salt: $\text{Acid} + \text{Base} \rightarrow \text{Salt} + \text{Water}$
 $\text{Acid} + \text{Reactive Metal} \rightarrow \text{Salt} + \text{Hydrogen}$
 $\text{Acid} + \text{Carbonate} \rightarrow \text{Salt} + \text{Water} + \text{Carbon Dioxide}$

Other Reactions of Acids

- 1. With Metals** – Acids react with many metals to produce hydrogen gas. They react rapidly with magnesium and zinc, slowly with iron and not at all with gold and copper.



- 2. With Carbonates** - Acids react with carbonates and release carbon dioxide gas.



Carbonic acid and hard water - Rainwater dissolves small amounts of CO_2 to form carbonic acid. This attacks rocks as rain falls to form soluble compounds. The main chemical formed in limestone areas is calcium carbonate. Most of the compounds wash away in rivers and reach the sea. If our tap water comes from these rivers it will contain dissolved salts which make it 'hard water'. It is hard to make soap lather and lots of scum is formed. When water with these compounds is heated a reaction occurs: Calcium hydrogencarbonate \rightarrow heat \rightarrow calcium carbonate + carbon dioxide + water
 Magnesium hydrogencarbonate \rightarrow heat \rightarrow calcium carbonate + carbon dioxide + water.
 The insoluble compounds settle out and cause limescale eg. in hot water pipes. These eventually become narrow and can block up.

Another group of 'water hardening' compounds sulphates eg. calcium and magnesium sulphate. These do not break down when water is heated and are removed with water softeners or by adding chemicals that react with them eg. sodium carbonate. Why do you think your kettle develops scale or 'fur'?

Acids and Bases in Everyday Life

Activity: Neutralisation

1. Put one of the sweets in your mouth and suck it. What does it taste like?
2. Put a little sodium bicarbonate on the palm of your hand.
3. Lick the palm of your hand to pick up some sodium bicarbonate.
Does it affect the taste of the acid sweet?
4. Repeat the experiment using some antacid on the palm of your hand.

Questions:

1. Look at the information on the sweet packet and see if you can find the name of the substance that gives it a sour taste.
2. What effect did the sodium bicarbonate and antacid have on the taste of the sweet? Explain what has happened in your mouth.
3. We use antacids for heartburn. What is heartburn and how does the antacid help relieve it?

Acid	General Information
Formic acid	Free in nature in small amounts; found in ants and stinging nettles; slightly stronger than carbonic acid with a sharp smell; used in the manufacture of salts and plastics.
Acetic acid	A weak acid found in vinegar; it is formed from the oxidation of alcohol that is produced from the fermentation of fruit juices eg. grapes. Vinegar acts as a preservative in pickles.
Lactic acid	Formed when lactose (milk sugar) is fermented by bacteria; found in sour milk, buttermilk and yogurt – used in baking as the lactic acid reacts with baking soda to form CO ₂ causing the dough to rise. When muscles contract, lactic acid is produced – if it accumulates it causes fatigue and stiffness.
Oxalic acid	One of the strongest naturally occurring acids; occurs in the leaves of vegetables such as rhubarb; used to remove iron stains from fabrics and china, and to bleach straw and leather goods.
Citric acid	Found in citrus fruits; produced commercially by a fermentation process from starch and molasses; used mostly in the food and soft drink industry to give a sour taste.
Benzoic acid	A colourless solid, slightly soluble in hot water; used in the synthesis of organic compounds and its sodium salt sodium benzoate is used as a preservative and antiseptic.
Ascorbic acid	Found in fruit and vegetables: essential in the human diet; is involved in the formation of collagen in connective tissue, is required for the metabolism of several amino acids, needed for the absorption of iron and important in immunity.
Tartaric acid	Found in grapes and wine: used in the food industry
Malic acid	Found in apples watermelons, grape juice & wine
Quinic acid	Found in cranberries



Experiment 2: Neutralisation Reaction

Aim: To show that a base reacts with an acid to produce a salt.

Method:

1. Add 2cm³ of dilute sodium hydroxide to a test tube.
2. Add a drop of bromothymol blue indicator. What colour is it? _____
3. Add dilute hydrochloric acid one drop at a time. Shake the test tube after each drop.
4. Add hydrochloric acid until the colour changes. What colour is it now? _____
5. Check the pH of the solution with universal indicator paper. Also taste it.

Result:

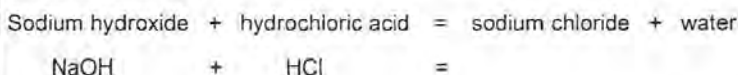
Table showing changes during the neutralisation reaction

Colour of indicator in sodium hydroxide	Colour of indicator after adding hydrochloric acid	Number of drops to change the colour	pH of solution at end	Taste

Conclusion:

The right amount of hydrochloric acid can neutralise sodium hydroxide to form a salt.

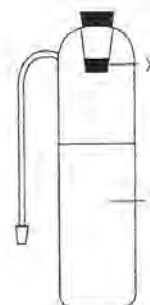
Chemical reaction:



Questions for Homework

Multiple choice – Make a cross over the letter next to the right answer.

1. When a metal reacts with a dilute acid it —
 - a fizzes to produce carbon dioxide gas
 - b changes the colour of the acid
 - c produces bubbles of hydrogen gas
 - d causes a slight explosion
2. Acids change the colour of litmus paper from —
 - a green to pink
 - b blue to red
 - c red to blue
 - d blue to yellow
3. Which of the following household substances is a base? (There may be more than one.)
 - a vinegar
 - b ammonia
 - c lemon juice
 - d oven cleaner
4. Which one of the following could be used to neutralise sulphuric acid?
 - a vinegar
 - b sodium hydroxide
 - c water
 - d hydrochloric acid
5. A fire can be put out using a fire extinguisher. It produces a gas. Which gas will put out a fire? _____
 To work this fire extinguisher you turn it upside down to mix the chemicals labelled X and Y. These chemicals will be:
 - a calcium carbonate and hydrochloric acid
 - b sodium hydroxide and hydrochloric acid
 - c calcium carbonate and water
 - d hydrochloric acid and water



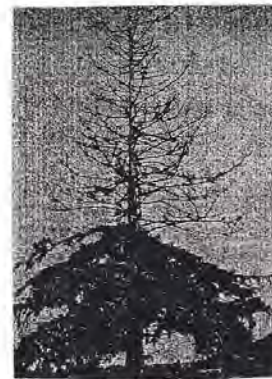
I. ACID RAIN

The death of trees due to acid rain is related to changes in pH which are brought about in the soil.

John set up a series of experiments to investigate the effect of acid rain on seed germination. He soaked separate pieces of filter paper in solutions with a range of pH values from pH 4 to pH 8. Then he sprinkled a handful of cress seeds onto each piece of paper. The filter paper and seeds were covered with a glass dish and left for one week in the laboratory.

John's results are shown in the table.

pH	Number of seeds which germinate	
Acid	4	0
	5	10
	6	64
Neutral	7	60
	8	52
Alkali	9	8



Effect of acid rain

TASKS

- Draw a bar chart to show the results. (3)
- State one way in which the method used by John could have affected the fairness of the investigation. How could this source of error be removed? (2)
- If the rain falling on an area of land over a number of years is highly acidic, predict what would be one of the effects on plant growth. (1)

2. Read the passage and complete the tasks which follow.

New Scientist

Acidic mouth and how to fight it

The cause of decay is acid, which is produced by bacteria whenever someone rinses their mouth with glucose, or some other fermentable substance.

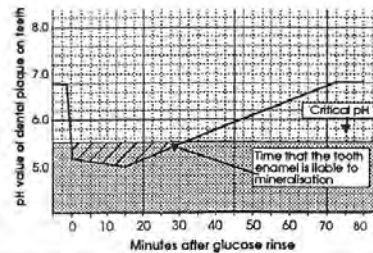
A graph of acidity, expressed as pH, plotted against time, shows how long it takes for the mouth to return to the resting (salivary) pH of about 6.7-6.8. This type of curve is known as a "Stephan curve".

The rate at which pH returns to the resting value depends mainly on the amount and duration of the glucose rinse, the rate of salivary flow, the buffering capacity of the saliva (that is, its ability to neutralise the acid).

If someone eats frequent sugary snacks, the pH of the mouth will probably not have returned to the resting value before the next snack and subsequent bout of acid production. Constantly sucking sweets, for example, can keep a mouth acidic for prolonged periods. Acid removes minerals from tooth enamel, and saliva encourages remineralisation, creating a dynamic equilibrium. But at around pH 5.5, there is a net loss of mineral: a point described as the "critical pH". The longer that

teeth are exposed to values around or below the critical pH, the more likely it is that they will start to decay.

Drinking fluoridated water produces a low level of fluoride in the body. If this is present when teeth are forming, some fluoride is incorporated into the enamel of teeth, making it more resistant to attack by acid. Fluoride toothpastes seem to act in another way, by promoting the remineralisation of early tooth caries.



TASKS

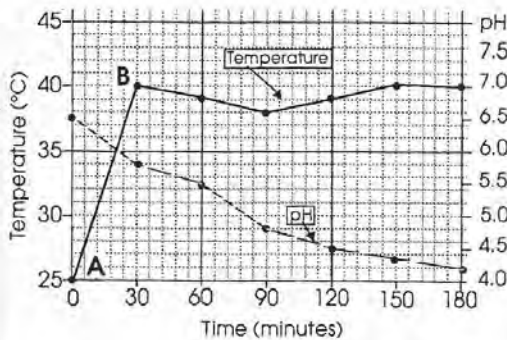
- Explain how the acid which causes tooth decay is produced. (1)
- What does the Stephan curve show (line 7)? (1)
- From paragraphs 1 and 2, identify two important functions of saliva. (1)
- State the effect of acid on tooth enamel. (1)
- Explain what is meant by the term *critical pH* (line 22). (1)
- Explain why continuous sucking of sweets increases the rate of tooth decay. (2)
- Using the graph, answer the following:
 - For how many minutes was the tooth enamel liable to mineralisation? (1)
 - Which has the greater effect on mineralisation: a second glucose rinse 30 minutes or 40 minutes after the start? Explain your choice. (1)
- From the last paragraph, state the different effects on children's teeth of taking fluoride in the diet or using fluoride toothpaste. (1)

3. YOGHURT

Yoghurt manufacture depends on the action, on milk, of several types of bacteria. The ideal temperature for yoghurt manufacture is 40 °C. Two types of bacteria act together to cause the milk to thicken and go sour. The sourness is due to the conversion of lactose sugar in the milk to lactic acid. When the correct level of acidity, taste and consistency is reached, the yoghurt is cooled. This slows down the bacterial activity but does not kill the bacteria. The lactic acid and low pH prevent the growth of other bacterial species.

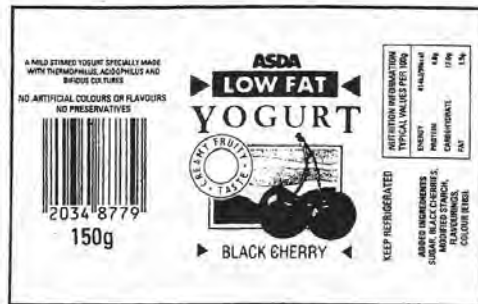
In an investigation into yoghurt manufacture, a pupil carried out the following procedure:

- 1 A water bath was set at 40 °C
- 2 200 cm³ of sterilised milk was placed in a sterile beaker and 5 cm³ of live yoghurt was added to the milk
- 3 The mixture was stirred and placed in the water bath
- 4 The temperature and pH were monitored, by two sensors, over a 3 hour period
- 5 The results are shown in the graph.



TASKS

- a Account for the slope of the graph between A and B. (2)
- b Account for the change in pH shown on the graph. (2)
- c What is the pH of the milk at the start of the investigation? (1)
- d Why is it important to use sterilised milk in the investigation? (1)
- e Explain why yoghurt should be stored at a low temperature rather than at room temperature. (2)
- f What control experiment should be set up in order to validate the results obtained? (1)
- g How could you demonstrate that 40 °C was the ideal temperature for yoghurt manufacture? (2)
- h Predict what results would be obtained if the investigation was repeated with 10 cm³ of live yoghurt being added to 200 cm³ of milk. (1)

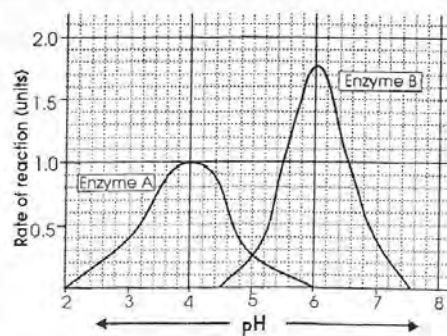


4. ENZYMES AND pH

The graph shows the rate of reaction of two enzymes A and B, over a range of pH values.

TASKS

- a State the pH range over which enzyme A is active. (1)
- b At which pH is enzyme B most active? (1)
- c State the pH range within which both enzymes are active. (1)
- d At which pH value would the rate of reaction of enzyme A and B be equal? (1)



Unit 4: Acid rain

Cars, factories and power stations burning fossil fuels pollute the air with gas **emissions** (refer to Unit 4 in Module 3). These emissions include gases such as sulphur dioxide and carbon dioxide.

Activity 4.1: The impact of acid rain on the environment (group activity – for assessment) NS LO2 AS1, 3; LO3 AS2

Did you know?

Is the rain in your area acidic? To find out, you can collect some rainwater in a container and test its pH, using one of the indicators you used in this module.

Rainwater is always slightly acidic. Its pH is about 5,6. Why is this? As rain falls from the clouds, the carbon dioxide from the air dissolves in water to form a very weak acid called carbonic acid. This might be one reason why rainwater tastes slightly different from tap water.

pure water + carbon dioxide → carbonic acid

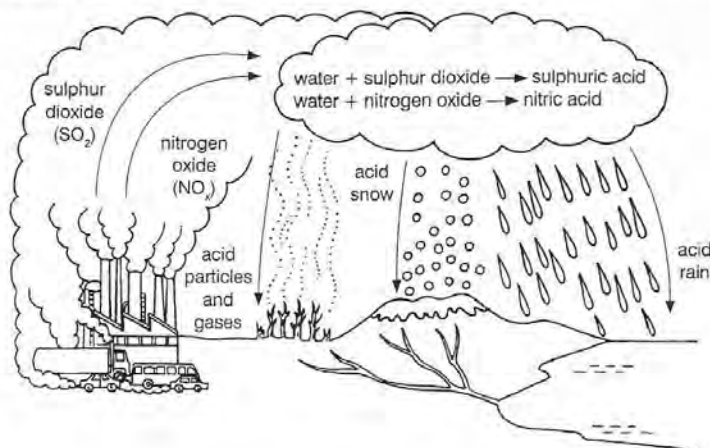
When the air is polluted, the rain can have a much lower pH than the 5,6 of normal rainwater. This rain is called **acid rain**. Acid rain is caused mainly by sulphur, sulphur dioxide and nitrogen oxide in polluted air. These pollutants react with rain water to form sulphuric and nitric acids which fall with the rain. It is a very serious problem in industrial areas, where smoke is being pumped into the atmosphere.

pure water + sulphur dioxide → sulphuric acid

Acid rain in South Africa occurs around places like Witbank, where coal is burned to generate electricity. The coal contains sulphur. When the coal is burned, the sulphur in the coal is also burned, producing sulphur dioxide which is released into the atmosphere. The pollution mixes with the rainwater to make acid rain.

Acid rain damages the environment in two ways:

- The acid in the rain damages plants and trees and buildings.
- The rainwater drains through the soil. This affects soil chemistry and causes rivers and lakes to become more acidic. This poisons the fish and the plant life in the water.



SOME LABORATORY RULES

ALWAYS WORK WITH CARE AND BE AWARE OF
YOUR SURROUNDINGS

- Do not run in the laboratory.
- Do not lean on the benches because apparatus can be knocked over.
- No eating or drinking in the laboratory.
- Never taste anything unless the teacher tells you to taste it.
- Do not smell the chemicals – fan the smells to your nose.
- Pour carefully so you do not spill.
- Wipe up spills immediately.
- Point the mouth of a test tube away from people.
- Be careful when heating substances.
- Always protect your eyes
- Wear your hair tied back.
- Don't be afraid to ask for help.
- Leave your desk clean and tidy.

NB: Call the teacher or lab assistant if you have a problem or if there is an accident.

ACIDS and BASES – using INDICATORS

- Scientists classify plants and animals into groups.
- Chemicals are also put into groups such as: **acid, base and neutral**.
- A **soluble base** is also called an alkali.
- **Indicators** can be used to find out if a chemical is an acid, a base or neutral. It must change colour to be sure.
- **pH** is a scale from 1 – 14 to measure how strong an acid or a base is.

Demonstration – using different indicators.

Fill in the table below as each indicator is used.

How some indicators change colour in acidic and basic solutions

Name of indicator	Colour at start	Colour when solution is acidic	Colour when solution is basic
Colour changing lipstick	green		
Phenol phthalein	colourless		
Methyl orange	red		

Experiment to find out whether some substances are acidic, basic or neutral.

Aim: To find out which substances are acids, bases or neutral.

Apparatus: Please check that you have the following apparatus.

Petri dish with red and blue litmus paper, yellow universal indicator paper and a colour chart.

3 watch glasses beaker with red cabbage indicator

6 droppers test tube rack with 6 test tubes labelled 1 – 6.

Bottles with: distilled water, hydrochloric acid (HCl), ammonia, lemon juice, vinegar and baking soda solution.

Method A

1. Put the 3 watch glasses next to each other.
2. Tear the piece of red litmus paper into 3 pieces and put a piece in each watch glass.
3. Repeat step 2 using the blue litmus paper.
4. Repeat step 2 using the universal indicator paper.
5. Put a drop of hydrochloric acid on the red and blue litmus paper in the first watch glass. Record what happens to the litmus in the table.
6. Put a drop of acid on the yellow universal indicator paper and use the colour chart to find the pH of HCl.
7. Using a dropper, put a drop of ammonia on each piece of paper in the next watch glass. Record the results in the table.
8. Using a clean dropper, put a drop of distilled water on each piece of paper in the last watch glass. Record the results. Then stack the watch glasses.

Results:

Table of the colour changes of acid – base indicators.

Chemical	Colour change with ...			pH
	Red Litmus	Blue Litmus	Universal Indicator	
Hydrochloric acid				
Ammonia				
Distilled water				

Method B

1. Use the droppers and add the chemicals to the test tubes 1 – 6. Look at the table.
2. Use the dropper to put 4 drops of red cabbage indicator in each test tube.
3. Note the colour change in each test tube and fill in the table below.

Results:

Table of colour change of red cabbage indicator in different substances

Number of test tube	Chemical	Colour with red cabbage	Acid/ Base/ Neutral
1	water		
2	hydrochloric acid		
3	ammonia		
4	lemon juice		
5	vinegar		
6	baking soda		

Note: Red cabbage indicator is pink in acids and green in bases.

Conclusion:

Which substances are acids, which are bases and which are neutral? Write a sentence.

Tasks for Homework

1. Complete the following sentences.
 - a) Litmus is an indicator. It turns _____ in basic solutions and _____ in acidic solutions.
 - b) A soluble base is called an _____.
 - c) Solutions may be acidic, basic or _____.
 - d) To be sure that a solution is acidic you must see a _____ in colour of an indicator.
 - e) Vinegar is _____ and ammonia is _____.
 - f) An example of a neutral liquid is _____.
2. What does the pH number tell you about a solution?

3. Read the following:

More about acids

When a bee stings you it is sore because the sting is an acid called formic acid. A wasp sting is also sore but it is an alkali. Oranges, lemons and other citrus fruit have citric acid in them and can taste sour. Yoghurt also tastes sour because it has lactic acid.

When you eat sometimes the food stays between your teeth. Germs in your mouth feed on this food and they produce acids which cause tooth decay. Toothpaste is slightly basic to neutralise the acids in your mouth. There is HCl in your stomach to help digestion of food. If you eat too much more acid is produced and you get indigestion. An antacid tablet helps because it neutralises the acid.

Doing Practicals - Important for Teachers

Acids and bases can be strong or weak. The standard laboratory acids and bases are mostly strong while the household ones are weaker, with some exceptions eg. caustic soda.

Strong acids and bases are **corrosive** (see demonstration). They can burn the skin and especially the eyes.

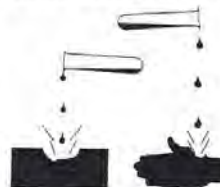


Fig. 6.9 This symbol warns that a substance is corrosive. It is found on containers of strong acids and bases

Safety while doing practical work with these chemicals is **important**. The learners must be told: **Handle carefully!** If acids or bases get on their hands or in their eyes **call the teacher and wash immediately with lots of water.**

If it is a strong acid neutralise with a weak base eg. bicarbonate of soda solution. With a strong base neutralise with a weak acid eg. vinegar.

❖ See sheet on SAFETY IN THE LABORATORY

Concentrated and dilute

To dilute an acid or base always ADD the concentrated ACID or base TO WATER – NOT water into acid.

- Always check the label on the bottle!
- Never taste or feel laboratory acids or bases.
- Use dilute laboratory acids rather than concentrated acids.
- When pouring put the mouth of the bottle on the mouth of the test tube and pour slowly.
- Don't lift the bottle by the stopper or the dropper – hold the bottom of the bottle.

Table 6.9 Laboratory acids and bases

Name	Formula	Dilute solution looks like	Ions it produces
Sulphuric acid	H ₂ SO ₄	water	H ⁺ SO ₄ ²⁻
Hydrochloric acid	HCl	water	H ⁺ Cl ⁻
Nitric acid	HNO ₃	water	H ⁺ NO ₃ ⁻
Ethanoic (acetic) acid	CH ₃ COOH	water, smells vinegary	H ⁺ CH ₃ COO ⁻
Sodium hydroxide (caustic soda)	NaOH	water	Na ⁺ OH ⁻
Potassium hydroxide (caustic potash)	KOH	water	K ⁺ OH ⁻
Ammonium hydroxide (ammonia solution)	NH ₄ OH	water, may smell of ammonia	NH ₄ ⁺ OH ⁻
Calcium hydroxide (limewater)	Ca(OH) ₂	water, may be cloudy	Ca ²⁺ OH ⁻ × 2

How to make Red Cabbage Indicator:

- Chop up a few red cabbage leaves.
- Place in a pot and add water to cover the chopped cabbage
- Boil for 5 – 10 minutes until the cabbage loses its colour.
- Strain the mixture to remove the cabbage and collect the coloured juice.
- Let it cool before using.
- It can be stored in the fridge for a few days, but if the colour changes to pink it is going off and fresh indicator must be made. (Acids form as it goes off!)

BRAINSTORM (5 minutes):

How could you do the experiment using red cabbage indicator with your class?
You need a known acid, base and neutral substance to use and some unknown ones.
What containers can you use?
What else do you need? What can you use for this?

Which water is suitable as a neutral substance?

- You have five bottles of water that are labelled and two pieces of universal indicator paper.
- Tear each piece of universal indicator paper into three pieces. Use the pieces to test the water in the bottles. Read the pH from the charts.
- Fill in your results below:

Water	Mineral W	Rain water	Oatlands Tap W	Fingo Tap W	Soda water
pH					

Try to explain these results.

Appendix J: Showing learners' translation of Oshiwambo to English

My focus Questions	Learners' in Oshiwambo	Learners' translation	My translation of learners' Oshiwambo
<p>1. What are things did you know about acids and bases?</p> <p><i>[oshike wa li ushi kombinga yo acids no beisa]</i></p>	<p><i>Ka kwali ndishi nande osha kombinga yiinima mbyoka. Ashike paife onda tseyo oshindji kombinga yo acids and beisa konima sho weyi tu longo. Ngaashi oombu, oompeke, nosheshete na ayihe mbino oyina omulyo omulula, gwafa omutoye. Nokombinga yo bases, ngaashi, omutoko, elyata nombundjambundje na ayihe mbika oha yi longithwa momagumbo getu oku yeleka illongithwa momagumbo.</i></p> <p><i>Ngaye nangaye kandali nana ndishi sha kombinga yoacids and bases, ashike sho we tulongo, onda tseyo kutya obase ohayi longithwa oku opaleka iinima yo ohayi ningi omuntu a kunge ngele eyi li. No acida ohayi liwa ndele oyina omulyo gumwe gwafa omomngwa.</i></p>	<p>I was do no anything about acids and bases. But now, I know a lot of different things about acids like, oombu, osheshete oompeke and all these have sour tests. And about bases are such as ash, elyata and mbundjambundje, and these are the only materials that used in our houses to clean our tools in the house.</p> <p>I wasn't know as well about acids and bases but now I learnt that acid can be eaten but they have sour taste and base are thing that can make you to vomit if you eat them.</p>	<p>I did not know anything about acids and bases. However, I only came to know and learn about acids and bases after the class we had with you. Now I know things like oombu, oompeke, osheshete that are acidic, because these kind of fruits have sour taste. About bases I also learnt things such as ash, elyata and mbundjambundje that are basic. These materials can be used to clean dishes and about anything in our homestead.</p> <p>I did not know anything as well, but after the lessons I now know a lot about acids and bases. I learnt that acids have a sour taste and can be eaten. While bases are the cleaning materials and if eaten can cause nausea.</p>
<p>2. How the lessons on acids and bases were and what</p>	<p><i>Ootundi odha li oombwanawa lela na odha longandje nenge odhe tu longa opo tu dhimbulukwe nawa</i></p>	<p>The lessons was very good and made me/learners to remember well how to use how to use</p>	<p>The lessons were good. We learnt a great deal on how to make use of acids and bases. I also</p>

<p>scientific concepts did you learnt? [ootundi odha li ngiini ano? Na ou ilongo mo shike]</p>	<p><i>kombinga yo acids and bases, shaashi ondi ilongo mo kutya ine pumbwa nande nande ompito yasha ndi kalande iinima moositola. Ihe onda pumbwa okugongela iininma yandje ngayemwene momukunda nenge momudhingoloko gwe gumbo.</i></p> <p><i>Ootundi odhali ombwanawa lela molwashoka ondi ilongomo iinima oyindji mbyoka kandali ndi yishi nale. No ondi ilongomo nkene okafo oka litusm paper ha ka shendje ngele okatiligane oha ka ningi oka blue, ngele oka blue timus oha ka shende e ta ka ningi oka red.</i></p> <p><i>Ootundi dhodhene odha li oombwanawa no kwali oohokithi. Ondi ilongomo inima nzoka yina ocida no bases nzoka ka kwali nda lonwa nale noshowo ondi ilongomo kutya ocida no bases oha yi adhika peni. Noshowo kutya ngele owa tula oka litmus paper blue momayeye ota kanningi okatiligane shashino omayeye ogena ocida nongele oka litmus paper red momeya</i></p>	<p>things about acids and bases, because I learnt that I don't have time anymore to go buy things from shops. So, I need to collect my own things materials from the village or around the house.</p> <p>I learnt more on acids and bases scientific. That leason it was very good and I learnt more thing like how litusm paper will change it turn red litmus paper blue and it the blue litmus paper change red colour.</p> <p>The leasons they were good and they can't make you sleep because we have were learning things that contain acids and bases were to find them and their uses. We learn the properties of acids and bases like; ACIDS they have sour taste, they are corrosive. Properties of Bases, they have beater taste, they turn red litmus paper blue.</p>	<p>learnt that I do not have to buy soaps from the shops anymore, as I can make use of locally available materials from my environment.</p> <p>The lessons were very good. This is because I learnt many things that I did not know before. I learnt things like how the litmus paper keep changing colour. A red litmus paper can change to blue and vice versa.</p> <p>The lessons were good and not boring at all. I learnt things that contain acids and bases that I was never taught before. I also learnt that in the saliva there is acid, because it turns blue litmus paper red. And that red litmus paper turn blue if you put it in a mixture of wood ash and water.</p>
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	<i>gomutoko ota kaningi okabulawu.</i>		
<p>3. What did you learn during the practical activities using locally available materials? [shi kwali a mu ningi oopracticals tamu longitha iinima mbi nde mu tuma, osha li ngiini, na ou ilongo mo shike?]</p>	<p><i>Oshali oshiwana noonkondo shashi no ka kwali tushi iinima mbi hatu longitha momagumbo getu oyina nana ocid nenge obases. Ngaashi hatu li ombeke oondulu tse katushi ngele inima mbi hatu longwa haku tiwa ocid no base ohay adhika nana moshike.</i></p> <p><i>Shi kwali oopractical okwa li oshi pu oku yamukula omapulo noku tseya oshindji kombinga kutya acids iinima ya tya ngiini no base. Etompelo lokuninga e practical oku ninga experiment opo to yolola ocids no base, nondi ilongomo oshindji lela.</i></p> <p><i>Mbino okwali iiwanawa nokwali nda kumwa shaashi ondi ilongomo kutya iinima oyindji mbi yina omulyo gwafa omululu oh yi vulu okushendja uumapila wo litmus momalwaala galwe nondi ilongomo kutya iinima yo base otayi vulu yi kwee hameke uuna we yi li.</i></p>	<p>It was very interesting for me to be told about things that we used in our dairy life that there are some that contain acids and bases.</p> <p>It was good to do practical activity and easy to answer the question. The reasons of doing practical is to make the experiments to differciat, which one is base and acids.</p> <p>These it was so wonderful and I was surprised, because I learnt that many things that have sour test can change litmus paper's colours and I learnt that materials for bases can make you ill when you eat them.</p>	<p>The practical were very interesting to learn that some of the things that we use daily contain acids and bases. But we never really knew them before.</p> <p>The practical activities helped us to answer the questions very easily. The reasons of doing practical are to differentiate between things that contain acids and bases.</p> <p>The practical were so much interesting and I was really amazed to learn that most things that have a sour taste are acids. And that bases can make someone sick if consumed.</p>

<p>4. Do you think it is useful or not for me to consider your prior everyday knowledge before the actual teaching? [owu wete ngaa sha li sha kwathela oku ilonga sha, shi nda li nde mupula tango shoka mushi combing yo acids no base]</p>	<p><i>Okwali oshivanawa noonkondo na nashi tsikile gaka oshoka out na okutseya tango kutya oshike hatu longitha momagumbo nzoka yina ocids no base opo nasho tatu kiilonga ocids nobase oshike nokutya ohaya longithwa shike, opo nasho tatu kiilonga otushi kutya ohayi adhika peni.</i></p> <p><i>Eeno okwa li sha kwathela oku ilonga kutse kombinga yo (topic) ndjika opo tu yu uveko tse tu hokwe oshilongwa.</i></p> <p><i>Iya oshili nawa! No sha li sha simana kalongwa ayehe. Payife oshili oshi pu kungaye oku nyongela no ku yolola acid nobase. Namba kwali ya shisha kombinga yo acida nobase payife ngeyi omulumentu nenge omukadhona okuna oku uvako nawa oku tala kiiholelwa. Oshivanawa kaalongi okutuma nege okupula kutya oye shi shike kombinga yo topic topic ndji mwipyakidhila nayo.</i></p> <p><i>Lelalela, shino oshali oshinima sha simana moshilongwa shino nda tsakaneka.</i></p>	<p>It was very interesting for me to be told about things that we used in our dairy life that there are some that contain acids and bases.</p> <p>Yes it was help us to study and to know more about this topic to understanding this subject.</p> <p>Yes it is ok! And it was very important to all learns. Naw it is easy to me to classify all the examples of acids and bases and who was don't know about acids and base that way he/she may going to understand by looking at the examples. Is good to the teacher to send or to ask what their now about the topic that you dill with.</p> <p>Diffinetly, this was a great job-lessons that I met in the subject</p>	<p>Its good and I want the trends to continue. This is important because if we know that are acids locally available then we have no problems understanding the acids and bases from the laboratory. And this will also help us when we study for examinations and tests.</p> <p>It really helped a great deal to understand this topic very well. It also makes us to love the subject.</p> <p>It is good to ask what the learners already know about the topic to be discussed. Specially sending the learners to collect locally available materials to use as an example. This helps us learners not to forget because 'we will look at the examples'.</p> <p>Definitely, the</p>
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<p>5. Any other thing?</p>	<p><i>Shaashi paife ondi shi shi kutya ocids no bases oyi li kombinga yashike nondishi okuyi longitha momikalo dha yololkathana, shaashi kakwali ndi shishi nale sha kombinga yo acids nobases moshilongwa shika nopaiife ondishishi thiluthilu.</i></p> <p><i>Eeno, onda hala ala okupandula tate Kambeyo kwaashoka wa ningilandje, shaashino paife ondina uunongo nkene okulongitha ayihe kombinga yo acids and bases.</i></p> <p><i>Oway ndjono yo kutuma nenge okupula aalongwa kutya oye shi shike kombinga yaasho, otayi kwathele aalongwa ya tseyesha oshindji.</i></p> <p><i>Ando okwali ne aalongi yetu yonale oyetu longele ngeyi... ando otwa adhika twa tseye nawa.</i></p>	<p>because now I know what acids and bases all about and I know how to use them now in many different ways, because I never knew about these subject of acids and bases before and I now know about them.</p> <p>Yes, I only want to thank Mr Kambeyo for what you did for me, because now I have skill on how to use all about acids and bases.</p> <p>That way of send or asking learners what they know about it before start teaching.....</p> <p>I just want to say if the previous teach have told us about this thing than there are properties and common acids like are citric acids found in <i>ombeke</i> things that we use in our dairy life and nitric acids found in fertilizer.</p>	<p>lessons were good. And its very important for the teacher to consider what the learners already know before the actual teaching. I learnt so many things about acids and bases and how are they used in so many different ways.</p> <p>Just to thank Mr Kambeyo for what you did. I now have more insights on what acids and bases are and how to use them.</p> <p>Just want to commend on the methodology used. It really helped the learners to know more about the topic to be learned.</p> <p>I just want to say that if our previous teacher could have used the same methodologies like you then we would have learnt more. Like now I know that in <i>oombeke</i> there is citric acid and nitric acids found in fertilizers.</p>
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