Exploring how Grade 11 Biology teachers mediate learning of osmosis when using easily accessible resources in the Oshikoto Region, Namibia

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MASTER OF EDUCATION

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By

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DECLARATION OF ORIGINALITY

I, Rosalia Ndawapeka Nangolo declare that the study: *Exploring how Grade 11 Biology teachers mediate learning of osmosis when using easily accessible resources in Oshikoto Region, Namibia* is my original work. Where contributions of others are involved, every effort has been made to reference and acknowledge their work.

Signature:  14 December 2018

DEDICATION

This thesis dedicated to the following people:

My late Grandmother, Tuyenikelao Ndiikwete Sheehama.

My dear husband, Karl N. Nangolo and our lovely children Prince and Teopolina.

ABSTRACT

Exploring the use easily accessible resources to carry out the hands-on practical activities to science learning has become one of the significant aspects in the educational research, particularly in science education. It could be deduced from the literature that hands-on practical activities are useful, enjoyable and foster conceptual understanding. The National Curriculum for Basic Education advocates empowering teachers to be knowledgeable on use of hands-on practical activities to produce learners who are scientifically equipped. Yet, the performance of the learners in Science and Mathematics continues to be worrisome and has not been improving over years as reported in TIMSS reports. For instance, the Namibian Examiners' Reports have repeatedly reported that Biology is one of the subjects that are poorly performed. Essentially, the section on osmosis has been identified as one of the scientific concepts that is problematic to learners. In my view, in order for learners to understand osmosis and its associated concepts, there is a need to strengthen the use of hands-on practical activities. It is recognized that this is something that is lacking in most rural Namibian schools especially where laboratory resources are scarce. It is against this background that the goal of this study was to explore how Grade 11 Biology teachers mediate learning of osmosis when using easily accessible resources.

This study is underpinned by an interpretive paradigm. Within the interpretive paradigm, a qualitative case study approach was employed to obtain in-depth understanding on how Biology teachers mediate learning. This study was conducted in two conveniently selected secondary schools in the Oshikoto region, which I could easily access. It focused on four Grade 11 Biology teachers. Data were generated through semi-structured interviews, workshop discussions, lesson observation and stimulated interviews. Vygotsky's (1978) socio-cultural theory was used as a lens to analyse my data.

The findings from semi-structured interviews revealed that teachers demonstrated positive attitudes towards teaching of osmosis using easily accessible resources. However, challenges regarding inadequate materials that hinder the teaching and learning process were registered. Another finding of this study was that teachers used a variety of mediation tools such as prior and local knowledge, language and easily accessible resources to enhance learning. The study thus recommends that, if teachers are exposed to numerous professional development platforms that include the use of easily accessible resources might improve their pedagogical approaches.

Key words: Biology, osmosis, practical activities, easily accessible resources, socio-cultural theory

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LIST OF ABBREVIATIONS AND/OR ACRONYMS

B.Ed	Bachelor of Education
BETD	Basic Education Teacher's Diploma
CoP	Community of Practice
DNEA	Directorate of National Examinations and Assessments
EFA	Education for All
GRN	Government Republic of Namibia
LCE	Learner Centred Education
MoE	Ministry of Education
NCBE	National Curriculum for Basic Education
NIED	National Institute for Educational Development
NSHE	Natural Science and Health Education
NSSC	Namibia Senior Secondary Certificate
NSSCO/H	Namibia Senior Secondary Certificate Ordinary/ Higher Level
PCK	Pedagogical Content Knowledge
PD	Professional Development
SACMEQ	Southern and Eastern Africa Consortium for Monitoring Educational Quality
SEO	Senior Education Officer
TIMSS	Trends in International Mathematical and Science Study
UNESCO	United Nations Educational, Scientific and Cultural Organization

CHAPTER ONE: SITUATING THE STUDY

1.1 INTRODUCTION

The goal of this study was to explore how Grade 11 Biology teachers mediate learning of osmosis using easily accessible resources. The study was triggered by repeatedly poor performances in science subjects, particularly Biology. As repeatedly reported in the Examiners' reports for Namibia Senior Secondary Certificate Examinations, learners continue to perform poorly in Biology; and specifically, in questions based on osmosis. Literature reviewed revealed various aspects that could contribute to such performance such as inadequate supply of laboratory equipment to schools and lack of laboratories. It is against this background that I decided to carry out a study in the form of an intervention with Grade 11 Biology teachers focusing on hands-on practical activities using easily accessible resources when mediating the learning of osmosis.

In this chapter, I discuss the context of the study both internationally and regionally, as well as in the Namibian context. The statement of the problem is highlighted followed by the significance of the study, research goal, objectives and research questions. Afterwards, I discuss the conceptual and theoretical framework that informed my study. The data gathering techniques that collected data in this study were also highlighted; followed by ethical considerations, definition of concepts, and the outline of the thesis. Then, the chapter ends with the concluding remarks.

1.2 CONTEXT OF THE STUDY

The context in this study is used to provide in-depth information related to the background that is presented in the research problem (Ben-Zvi & Gil, 2010). In this case, McMillan and Schumacher (2010) indicate that context would help the reader to understand the importance and the contribution of the study to the worldview. This study is contextualised within international and regional contexts, as well as the Namibian context. The next section provides the background of this study from the international and the regional contexts.

1.2.1 The international and regional contexts

The poor performance in science subjects was reported to be worrisome worldwide (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2010; Science, Technology, Engineering and Mathematics [STEM], 2016). The Trends in International Mathematics and Science

Study (TIMSS) that provide reliable and timely data on Mathematics and Science achievements of more than 60 countries, confirmed a very minimal improvement in some participating countries, and noted a decline in performance on average scores in 2015 (TIMSS, 2016). Although, TIMSS took place for the sixth time in 2015, only two Southern African countries took part; namely, South Africa and Botswana. Compared to other countries, the performance of these two African countries was not pleasing in Mathematics and Science (TIMSS, 2011, 2015). The Centre for Development and Enterprise (CDE) which aims at improving the National Education System indicated that South African learners' performances were the lowest among the middle-income countries that participated (CDE, 2013). With regards to the quality of teaching of Mathematics and Science, the World Economic Forum (WEF) in the Global Information Technology Report of 2015 indicated that South Africa was ranked last (Writer, 2015). Similarly, the study carried out by King'aru (2014) in Tanzania on exploring the factors affecting the performance in science confirmed that performance in science subjects was poor. Some of the challenges highlighted in the study were lack of resources as well as ill-equipped laboratories. Namibia is no exception to the aforementioned challenges which hamper effective teaching and learning of Mathematics and Science. The next section provides the background of the study in the Namibian context.

1.2.2 Namibian context

The National Curriculum for Basic Education (NCBE) that ensures consistency in delivery of the curriculum in schools, expects to produce learners that are well equipped and that demonstrate quality learning that leads to high performances (MoE, NCBE, 2010). The curriculum states that:

> *Teachers are equipped with all the necessary teaching aids, technology and other relevant materials to support effective learning and have the skills to develop and adapt materials themselves to suit multi-ability groups of learners. (MoE, NCBE, 2010:1)*

The NCBE (2010) further indicates that it provides information regarding the syllabus, learning materials and textbooks that teachers may use when planning for schemes of work or lessons. The National Curriculum for Basic Education (NCBE) in Namibia advocates for the learner-centred approach for teaching and learning whereby learners are expected to learn by doing and sharing with others what they already know and what they can do, as part of knowledge acquisition (MoE, NCBE, 2010). The introduction of LCE in the national curriculum was done to recognise the uniqueness of the learner and adhere to the philosophy of learner-centred education (Nyambe, 2008).

Table 1.1: An extract from the MoE, NCBE (2010) about LCE

Ref. to LCE	Learners must be able to work effectively, independently and in groups; build on their own learning experiences, cultural backgrounds and preferred learning styles; develop sound work habits; and take increasing responsibility for their own learning and work. Learning to learn in Basic Education provides the skills and habits for productivity and lifelong learning (p. 10).

With reference to the extract, Basic Education in Namibia is based on the learner-centred principles to develop and produce learners who actively construct and create from experiences and interactions within socio-cultural contexts (MoE, Basic Education Teacher's Diploma [BETD] Broad Curriculum, 2007). Moreover, the NCBE (2010) provides a green-light for all the subjects offered in the Namibian curriculum to be mediated in such a way that there is a new understanding, new skills, and creation of new knowledge. Besides, the Namibia Senior Secondary Certificate Biology Syllabus is also grounded on the learner-centred education (LCE) framework (MoE, National Subject Policy Guide for Natural Science, 2009). Biology being a practical subject, learners need to be actively involved in the lessons. In this case the Biology SSCO Syllabus (2010) indicates that learners are expected to actively participate, design and carry out demonstrations or investigations to prove the facts in the science content.

Despite the curriculum expectations, the performance of the learners in Science and Mathematics continues to be worrisome and has improved over the years (UNESCO, 2010; MoE, Examiners' Reports, 2010, 2016). The Southern African Consortium for monitoring of Education Quality (SACMEQ) report indicated that, teaching Mathematics in Namibia has been unimpressive, especially in the upper primary phase (SACMEQ Report, 2004). The SACMEQ Reports (2004, 2011) confirmed that Namibia's performance has been very poor compared to other Southern African countries.

Reports have revealed that according to the Standardised Achievement Tests (SATs), administered for Grade 7 (of which Science is one of the subjects), to measure the attainment of basic competencies of the syllabus, learners' performances were below the basic or average achievements, especially those in rural schools (MoE, SATs Report, 2011, 2013, 2015). The study by Shaakumeni (2014) for instance, confirmed that most learners showed limited knowledge and exposure to some of science's basic competencies, as they performed poorly. The poor performance in Biology especially in the practical related questions was also cited in the examination reports for Namibian Senior Secondary

Certificate (NSSC). The Examiner's Reports indicate that the ability of candidates to answer Biology practical questions has been worrisome and shows no significant difference over the years (MoE, Examiners' Reports, 2008, 2017).

NSSC is offered on two levels (Ordinary and Higher Levels) according to the subject policy guide for Natural Science and Health Education, Life Science and Biology (2009). However, in this study I focused on the ordinary level, where the performance is poor compared to the higher level, as indicated in the analysis of the national examination results (MoE, Examiner's Reports, 2015, 2016). In the Biology syllabus (2010), there are suggested practical investigations at the end of every section that need to be carried out and demonstrated by the learners; however, most of them require advanced laboratory preparations. This is challenging in a situation of scarce resources. For instance, the Examiners' Reports indicate that only few schools follow the practical approach to teach practical concepts in Biology, and it could be that some schools are experiencing challenges in preparing the practical investigations as learners are under performing (MoE, Examiners' Reports, 2012-2016) (see Appendix 10).

In reference to the Examiners' Reports, learners are being challenged in Biology, and more specifically on the questions that need practical knowledge and skills to understand science concepts. *Osmosis* is one of the concepts in Biology which has been identified as challenging in terms of understanding and application to different life contexts due to the lack of exposure to practical lessons (MoE, Examiner's Report, 2009, 2016). The latest versions of the Examiner's Reports (2016, 2017) state that some learners could not even differentiate between *osmosis* and *diffusion* and hence failed to show good concept interpretation in their answers, based on the given contexts. Conceptually, osmosis is the movement/passage of water molecules from a region of high(er) water potential to the region of low(er) water potential through a partially permeable membrane down the water potential gradient (MoE, NSSC Syllabus, 2010; De Klerk, 2013) (See Appendix 10).

Table 1.2: Extract from Biology NSSCO Syllabus (2010)

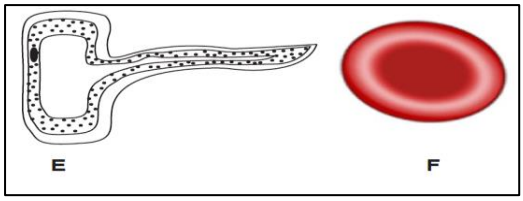
Topic: Passage of Substances	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
4.2 Osmosis	Understand the concept of osmosis as the movement of water molecules across	• define **osmosis** as the passage of water molecules from a region of their *higher water potential* to a region of *their lower water*

	a partially permeable membrane	*potential* , through a partially permeable membrane • describe the importance of osmosis in the uptake of water by plants • describe the effects of osmosis on plant and animal tissues

With reference to the extract above, the curriculum demands that learners understand the concept of osmosis from the broader perspective and apply it to real life situations, which poses a challenge. Learners are expected to understand osmosis as the movement of water molecules across a partially permeable membrane (MoE, Biology NSSCO Syllabus, 2010). That is to say, learners should be able to define osmosis, describe its importance to organisms' cells and its effects on cells or tissues.

Besides the curriculum expectations, learners repeatedly performed poorly during the external examinations in almost all osmosis related questions appearing in paper 2 and 3. The extract in Appendix 10 summarises the comments made by the examiners in different years on the questions contextualised within the osmosis concepts.

It is evident that learners struggle to answer very simple questions on osmosis and continue making mistakes which leads to an unnecessary loss of marks. The extracts further indicate the repeatedly poor performance in Biology over the years as reported in various examination reports (MoE, Examiners' Reports, 2008-2017). The Examiner's Report of 2016 acknowledged that some concepts are very difficult for learners to explain in their own words, thus exposure to practical activities may boost their practical knowledge. Similarly, Nelson (2017) perceives osmosis as a challenging concept and difficult for learners to understand. Wren and Wren (2016) point out that, in order for the learners to develop the ability to demonstrate processing skills to carry out practical activities effectively, learners should be able to use the theoretical knowledge obtained during teaching and learning to understand the intended concept. I next discuss some of the extracts from the external examination papers for Namibia Senior Secondary Certificate Examination to indicate the nature of the question, expected answers and how overall learners answered. The figure below shows two cells which play a role in transport in either plants or animals.



Question: Cell **F** is placed in distilled water. Explain what happens to the cell.

Expected answers: (from MoE, Examiner's Report 2017:45): *Water enters the cell/ endosmosis; cell swells / becomes turgid; will burst; because cell has no cell wall; max [2 marks]*

Figure 1.1: Examination Extract 1, Paper 2 NSSCO, 2017:5 (practical question)

This was regarded as an easy question and learners used their practical knowledge obtained from the classroom to answer such a question. As a result, the Examiner's Report (2017) indicates that some learners were confused by some terminologies such as *plasmolysis*, *shrink* and *turgidity*. Learners explained the plant cell instead of the animal cell (F) and many wrote the definition of osmosis without an indication of where the water was coming from and going to (*ibid*.).

Although most of the learners could identify the correct solutions, they failed to understand that osmosis was taking place. However, they were challenged and lost marks because they omitted to make reference to osmosis and placed emphasis on the differences in sugar concentration rather than water potential (MoE, Examiner's Report, 2010). They also failed to give a full explanation with reference to water moving in and out of epidermal cells or vacuoles and linking it to change in length (*ibid*.).

In addition to the above, I decided to focus on osmosis because, as per my observations and experience as a teacher, a Senior Education Officer and a National Marker for Life Science and Biology, it is one of the most challenging concepts in Biology. Yet, learners are expected to design and carry out experiments to investigate osmosis and be able to apply it to show a broader understanding of the concept (MoE, NSSC Syllabus, 2010). In most instances, learners struggle to apply everyday/prior knowledge or relate the concept osmosis to their daily life situation. Even more, Roschelle (1995) indicates that neglecting prior knowledge can lead to misconceptions, because learners tend to construct concepts from prior knowledge.

Some of the findings from studies reviewed indicated that the poor performance in science subjects might be due in part to insufficient or unavailable laboratory facilities/under-resourced laboratories;

the general perception being that laboratories should be well resourced to carry out practical investigations (Nakale, 2012; Frans, 2015). Some similar studies reviewed focused on the use of easily accessible resources to make sense of science concepts. Conducted by Asheela (2017), Kambeyo and Ngcoza (2017) and Samuel (2017), these studies focused on different Physical Science concepts. For instance, Asheela's (2017) study findings revealed that for teachers to be able to use easily accessible resources to carry out practical activities in their science classrooms, they needed the knowledge and exposure on how to use these resources. Kambeyo and Ngcoza (2017) found that, conducting practical activities with improvised materials resulted in the same level of performance as the standardised materials. Samuel's (2017) findings revealed that easily accessible local sourced materials were found to have the potential to make sense of concepts, especially in under-resourced schools.

These studies motivated me to explore how teachers mediate learning of osmosis, using easily accessible resources, as I could not find any study in Namibia which deals with this aspect of research.

1.3 STATEMENT OF THE PROBLEM

The Namibian Examiner's reports have repeatedly reported that Biology is generally poorly performed in most rural schools. Osmosis is one of the science concepts that has been reported as problematic to learners. In my view, in order for learners to understand osmosis and its associated concepts, they need to do hands-on practical activities. This is something that is lacking in most rural Namibian schools. It is against this background that in this study I aimed to explore how Grade 11 Biology teachers mediate learning of osmosis when using easily accessible resources.

1.4 SIGNIFICANCE OF THE STUDY

Since I intended to co-plan model lessons during the workshop on the use of easily accessible resources to mediate learning of osmosis, the teachers that I worked with might acquire knowledge and skills on hands-on practical activities for their lessons. The study may sensitise the other Biology teachers on the use of easily accessible resources, rather than relying on complex laboratory equipment which is very expensive and not easily accessible. Lastly, this study may benefit me as a Senior Education Officer (Biology Subject Advisor) on how to conduct professional development workshops and support for teachers as evidenced by Asheela (2017).

1.5 RESEARCH GOAL AND QUESTIONS

This section introduces the research goal, main question and sub-questions of my study.

1.5.1 Research goal

The main goal of this study was to explore how Grade 11 Biology teachers mediate learning of osmosis using easily accessible resources. To achieve this goal, the study was guided by the following research questions.

1.5.2 Research questions:

1. What are the grade 11 Biology teachers' experiences, conceptions and dispositions towards the use of easily accessible resources when mediating learning of osmosis?

2. What are the enablers and/or constraints that Grade 11 Biology teachers encounter when developing model lessons on osmosis?

3. How do Grade 11 Biology teachers mediate learning of osmosis when using easily accessible resources?

1.6 CONCEPTUAL FRAMEWORK

A conceptual framework is defined by Adom, Huissein and Joe (2018) as a path of the research grounded firmly in theoretical constructs. Besides this, the conceptual framework consists of concepts interconnected to explain how the research questions were explored and how they assert to answer the research questions (*ibid*.). This study was informed by the concepts of conception, experiences and disposition of teachers when mediating the learning of osmosis using easily accessible resources. The conceptual framework lies within the broader context of the theoretical framework which I discuss in the next section.

1.7 THEORETICAL FRAMEWORK

A theoretical framework refers to structures that influence, hold and support the aspects of the research (Abed & Gabriel, 2008; Merriam, 2009). Adom et al. (2018) extend the definition, as a foundation upon which the research is constructed in terms of philosophy, epistemology and methodology. In this study, I used Vygotsky's (1978) socio-cultural theory as a theoretical lens. Vygotsky's concepts such as mediation of learning were introduced in this study to enhance professional practice and support during teaching of science (Harland, 2003). These two constructs

were used in this study to make the research findings more meaningful and valuable in the research fields, able to answer research questions (Adom et al., 2018). The next section highlights the data gathering techniques.

1.8 DATA GATHERING TECHNIQUES

In this study, data were collected using the following data collection techniques: semi-structured interviews; workshop discussions; observations (lessons); and stimulated recall interviews.

Afterwards, the data were analysed inductively using different analytical tools as discussed in Chapter Three. Data were further validated through piloting of the data collection instruments and triangulation.

1.9 ETHICAL CONSIDERATIONS

This study considered ethics as an underlying principle (Coe, Waring, Hedges, & Arthur, 2017) that ensures that the study followed the ethical procedures as per the university requirements. I considered issues with regards to respect and dignity, transparency and honesty, accountability and responsibility, integrity, academic professionalism and positionality in this study.

1.10 DEFINITION OF THE KEY CONCEPTS

Biology: is one of the Natural Sciences learning areas that deals with a study of living things and the environment.

Conception: refers to thoughts or ideas teachers have about teaching and learning (Kagan, 1992).

Easily accessible resources: refers to locally available improvised materials (Asheela, 2017).

Disposition: refers to beliefs and attitudes related to values such as caring, honesty, responsibility and social justice (Atallah, Bryant, & Dada, 2010).

Indigenous Knowledge (IK): refers to the understandings, skills and philosophies as a result of indigenous practices that local people do to understand a certain phenomenon through experiencing and carrying out informal experiments (Chikaire, Osuagwu, Ihenacho, Oguegbuchulam, Ejiogu-Okereke, & Obi, 2012).

Learner-Centred Education: is an approach where a learner is put at the center of the education process and actively engaged in his/her own learning, and the teacher facilitates or mediates learning (MBEC, 1999; Nyambe, 2008).

Mediation: involves the use of cultural tools such as language and materials to achieve the learning goal (Vygotsky, 1978).

Osmosis: is a movement/passage of water molecules from a region of high(er) water potential to the region of low(er) water potential through the partially permeable membrane (MoE, NSSC Syllabus, 2010).

Practical activities: refer to any teaching and learning activity which requires students to observe or manipulate objects and materials they are studying (Millar, 2004).

Prior knowledge: refers to knowledge the individuals already had before they are exposed to new information (Roschelle, 1995; Lee, 2007).

Professional Development: refers to a wide variety of specialised training where professional learning is expected to take place to improve professional knowledge and skills (Runhaar, 2008; Shabani, 2016).

Sociocultural theory: is a social learning theory that focuses on how learning occurs as a result of interactions and how culture, cultural beliefs and attitudes affect the interactions (Vygotsky, 1978).

1.11 THESIS OUTLINE

This thesis consists of seven chapters and I discuss these below.

Chapter One provided an overview of the study context. In the first part of this section, the context of the study which included the international, regional and Namibian contexts were discussed. The second part outlined the statement of the problem followed by the significance of the study, research goal, objectives and research questions. The third part highlighted the conceptual and theoretical framework that informed the study. The fourth part highlighted data gathering techniques used to

collect data and then the ethical considerations. The fifth part provided the thesis outline and the last part provides the concluding remarks.

Chapter Two provides an overview of the literature used in this study. The first part discusses the National Curriculum for Namibia, and Learner-Centred Education (LCE) broadly and then later in the LCE Namibian curriculum. The second part discusses the concept of osmosis in Life Science. The third part discusses easily accessible resources, IK and pedagogy used in the practical activities. The fourth part discusses the conceptual framework and theoretical framework that informed this study. The section ends with concluding remarks.

Chapter Three provides an overview of the qualitative research design and methodology used to collect, analyse and present data. The first part of this section gives a brief overview of the research design and methodology which was used in this study to gather data to answer my research questions. The second part of this section discusses the research paradigm, type of study, phases of the data collection process, sampling, data gathering techniques, data analysis procedures, validity and trustworthiness, ethical considerations and limitations of the study. The section ends with concluding remarks.

Chapter Four provides an overview of data presentation, analysis and discussion of the semi-structured interviews with the four Biology Grade 11 to answer my research question 1. These findings will be discussed in relation to the literature. This chapter ends with concluding remarks.

Chapter Five provides an overview of the findings aimed at answering the research question 2. I will discuss the presentation, analysis and discussion of the workshop discussions. The second part of this section involves the discussion of research findings in relation to the literature and theory. The third part highlights the findings from workshop 2. The fourth part presents, analyses and discusses workshop 3.

Chapter Six provides an overview of the findings of the data collected from the classroom observations of the two teachers and also from the stimulated recall interviews. This chapter aims to answer research question 3. In the process the findings will be analysed and discussed accordingly. This chapter ends with the concluding remarks.

Chapter Seven provides the summary of the findings as gathered, analysed and discussed in order to answer my research questions. Therefore, the first part will summarise the findings as presented,

analysed and discussed as per each research question. The second part I discuss the recommendation of the study. The third part I discuss further research that could be undertaken. The chapter ends with the concluding remarks of this study.

1.12 CONCLUDING REMARKS

Chapter One first described the context of the study internationally and nationally. Then, the significance of the study, the problem statement, research goals and research questions are discussed. Conceptual and theoretical frameworks are also highlighted. The data collection techniques and ethical considerations were highlighted. The key concepts were explained, and the chapter ended with a thesis outline. I the next chapter, I discuss literature relevant to my study.

CHAPTER TWO: LITERATURE REVIEW

2.1 INTRODUCTION

The goal of this study was to explore how Grade 11 Biology teachers mediate learning of osmosis using easily accessible resources. This section provides an overview of the literature used in this study. Mudavanhu (2017) defines a literature review as a synthesis and analysis of the published work of previous researchers. Therefore, it should focus more on a critical discussion that shows insight and awareness of different arguments, theories and approaches (Boote & Beile, 2005).

The first part provides an overview of the study as discussed above. The second part discusses literatures related to the Namibian curricula such as the National Curriculum for Basic Education (NCBE), Namibia Senior Secondary Certificate Syllabus for Biology, and the Learner-Centred Education (LCE) approach. The third part discusses *osmosis* as a concept in Life Science. The fourth part discusses the inclusion of practical activities pedagogy in biology teaching. The firth part discusses the use of easily accessible resources in science teaching and learning biology, and osmosis in particular. The sixth part discusses the use of IK in science teaching and osmosis. The seventh part discusses the conceptual framework using the key concepts such as *conception* and *dispositions* of Biology Grade 11 teachers when mediating the learning of osmosis using easily accessible resources; and then their *professional development*. The eighth part discusses the theoretical framework that informed this study with the focus on the key concepts of *mediation* of Vygotsky's sociocultural theory (1978). Lastly, the section ends with the concluding remarks.

2.2 NAMIBIAN CURRICULUM

Over the past decade most of the developing countries in the world have embarked on large education reforms to expand the availability of education, achieve equity in educational provisions and improve quality education for all (Tiongson, 2005; Wilmot, 2017). Most of the African countries including Namibia are challenged with implementing the reformed policies in ensuring that quality education prevails (UNESCO, 2013). After independence in 1990, the Government Republic of Namibia (GRN) underwent different educational reforms. Moving towards an independent Namibia, the following changes were noted as presented by Prof. Peter Katjavivi, Namibia Speaker of National Assembly at Commonwealth Conference (Commonwealth Council on Education, 2016).

- English as a language replaced Afrikaans as the national official language and medium of instruction;
- Learner-centered Curriculum for Grade 1-12 was developed (completed 1998);
- Grade 10 Junior Secondary Certificate was introduced in 1993;
- Adapted the Cambridge International General Certificate of Secondary Education (IGCSE) (1995);
- The second reform involved the introduction of the Namibia Senior Secondary Certificate Ordinary Level (NSSCO) and NSSCH, benchmarked against Cambridge IGCSE in 2006, and the first examination written in 2007; and
- The third curriculum reform was introduced from 2015 starting with the Junior Primary Phases. However, for Grade 10 and 11 it would commence (2019 and 2020 respectively). Senior Secondary Phase was benchmarked against Cambridge IGCSE. The Grade 12 Advanced Subsidiary Level would commerce in 2021, whereby both are benchmarked against Cambridge IGCSE and Advanced Subsidiary respectively.

Like any other country in the world, the Namibian education system is guided by various policies as constituted in the National Curriculum for Basic Education (MoE, NCBE, 2010). The educational policies are required to ensure equitable and quality education, and promote lifelong learning opportunities for all as per the Sustainable Development Goal 4 (United Nations, 2014). Amongst policies that govern education in Namibia, I will first discuss the National Curriculum for Basic Education and then, the Namibia Senior Secondary Syllabus for Biology Ordinary level.

2.2.1 Namibian Curriculum for Basic Education

The National Curriculum for Basic Education (NCBE) is the Namibian official policy that provides a framework for teaching, learning, and assessment in various subjects offered in schools. In ensuring the smooth running of the teaching and learning in Namibian schools, the NCBE for 2010 was developed to replace the Pilot Curriculum Guide for Formal Basic Education (1996) and the Curriculum Guide for Senior Secondary Education (1993) which were developed after Namibia gained independence in 1990 (MoE, NCBE, 2010). It was developed in response to the Constitution of the Republic of Namibia (Act 1 of 1990) as a fundamental law, and the Education Act of 2001 (MoE, NBCE, 2010, GRN, Education for All [EFA], 2002). It outlines the structures of the learning at any phase as further described in the syllabi, learning materials and textbooks (MoE, NBCE, 2010). This curriculum was thus developed to guide basic education towards the realisation of Vision 2030 that strives for Namibia to become a knowledge-based society (MoE, NBCE, 2010). A knowledge-based society means that citizens become innovative to contribute positively to their own wellbeing. In relation to this study, the role of improvisation and the use of easily accessible resources received

recognition in leading to a knowledge-based society (Pârgaru, Gherghina, & Duka, 2009; MoE, NBCE, 2010). I now discuss the Senior Secondary Syllabus for Biology in Namibia.

2.2.2 Senior Secondary Syllabus for Biology in Namibia

As part of Natural Sciences, Biology received recognition as one of the key areas where essential knowledge can be found and developed (MoE, NBCE, 2010). The Natural Sciences are comprised of Natural Science and Health Education (Grade 5-7), Life Science (Grade 8-10), Biology (Grade 11-12), Agriculture (Grade 5-12) and Physical Science (Grade 8-12). As part of Natural Science, Biology is one of the subjects offered at the Senior Secondary Level (Grade 11-12) as per the National Curriculum, Assessment and Certification Board for Formal Education (MoE, Namibia Senior Secondary Certificate (NSSC) Syllabus, 2010). Biology is offered at two levels (Higher and Ordinary), both designed as a two-year course, whereby the work is assessed in an external examination at the end of year two in Grade 12 (MoE, NSSC Syllabus, 2010). The MoE, NSSCO Syllabus (2010) indicates that learners are being assessed in three components in the NSSC Examinations, namely, Paper 1 (multiple-choice questions), Paper 2 (structured questions) and Paper 3 (applied practical skills). The NSSC Syllabi are Namibian based, internationally recognised and accredited by the Cambridge International Examinations [CIE], (MoE, National Subject Policy Guide for Natural Sciences, 2009). Currently, Namibia is in the process of reforming its curriculum as per approval by the National Examinations, Assessment and Certification Board (MoE, 2014). For instance, Natural Science and Health Education is now offered from Grade 4 - 7 (already commenced in 2016), Life Science is offered in Grade 8-9 (already commenced, as from 2017-2018) and Biology Ordinary Level will be offered in Grade 10-11 (commencing, 2019-2020), and then in Grade 12 with the Subsidiary Level (commencing, 2021) which are benchmarked against the Cambridge Advanced Subsidiary [AS] (MoE, 2014).

Biology is a practical science that requires quality, appropriate experiments and investigations which are key factors to enhance learning, clarification and consolidation of theory (Society of Biology, 2010). It aims at producing learners who can understand the use of their natural environment to satisfy human needs, and how environments may be changed by ecologically sustainable ways (MoE, NSSC Syllabus, 2010). Additionally, it uses a systematic way of acquiring and producing knowledge to equip learners with necessary knowledge, skills and attitudes that will help them to be scientifically equipped to face challenges in the world markets (MoE, Syllabus, 2010). One of the aims of the

NSSC Syllabus (2010) is to provide learners with scientific skills and knowledge to take or develop an informed interest in matters of scientific importance.

As indicated earlier in Chapter One, Namibia adapted the Learner-Centered Education (LCE) approach, whereby learners were considered as active agents able to influence their own learning (EFA, 2002; MoE, LCE, 1999). In the next section, I discuss the learner-centred approach in detail.

2.2.3 Learner Centered Education

Learner-Centred Education (LCE) has been endorsed by the international agencies and national governments (MoE, LCE, 2003; Nyambe, 2008; Schweisfurth, 2013, UNESCO, 2013) as a policy and democratic pedagogy used to improve the quality of teaching and learning in the classrooms (MoE, LCE, 2003). The LCE policy was formulated after Namibian independence in 1990 in response to the education reform of policies, curriculum review and national goals of access, equity, quality and democracy (MoE, LCE Policy, 1999; EFA, 2002).

The introduction of the Learner-centred Education (LCE) approach was informed by various theorists, in which Vygotsky (1978) was one of them. However, in broader perspectives, LCE is viewed as a response to the constructivist theory of learning which acknowledges that knowledge is mediated through social settings and interactions with the world around us (Vygotsky, 1978). In a constructivism setting, learning occurs as learners get actively engaged in activities and construct knowledge without relying on receiving the information as passive recipients (Weimer, 2013; McLeod, 2014). Learners are regarded as active agents that bring to school knowledge and social experiences from home, communities and environments and vice-versa (MoE, National Subject Policy for Natural Sciences, 2009). Thus, Vygotsky argues that the use of the learning-centred approach maximises effective learning as a result of social interactions (Vygotsky, 1978; Bunyakarte, 2010).

Learners have roles to play in their own learning processes. In this case, McRobbie and Tobin (1997) emphasise that learning with understanding will enable learners to accept responsibility of their own learning, explore knowledge and be able to resolve discrepancies between their own ways of thinking. This implies the core meaning of LCE pedagogy; where learners are recognised as active agents who understand their own learning without memorising the contents (Nyambe, 2008; Weimer, 2013). Nonetheless, teachers mediating learning in such ways could provide an opportunity for learners to have diverse experiences and varied exposure to interpret their own learning (McRobbie & Tobin,

1997). Concurring, Amineh and Als (2015) say that teachers are not there to give monologues that teach completely brand-new content lessons, but their teaching can be contextualised in such a way that prior or existing knowledge is utilised to make meaning of the new knowledge. This does not make the situation reciprocal. A teacher still holds the huge responsibility of ensuring that appropriate learning and tasks are completed, and the curriculum is effectively implemented (Massouleh & Jooneghani, 2012). Thus, the socio-cultural theory of Vygotsky (1978) stresses that the development of the learner is possible, and it is in the hands of the teacher's guidance (Pathan, Memon, Memon, Khoso, & Bux, 2018). Importantly, there is a need for the teachers to change their beliefs about teaching and adjust their pedagogy towards learner-centred approach (Amineh & Als, 2015).

2.2.3.1 Benefits of Learner-Centered Education

The LCE policy places more emphasis on putting learners at the centre of learning, while teachers develop activities that can stimulate prior knowledge, skills and understanding of topics (MoE, LCE, 2003). Learners at schools are expected to be actively involved in their own learning but not to be treated as empty buckets to be filled with information (MoE, LCE, 2003). LCE motivates learners to learn because they are engaged in the lesson (Schweisfurth, 2013). Due to learners' engagement in the LCE classrooms, they develop skills such as critical thinking, problem solving and cooperative working (Mendoza & Parra, 2016).

In cementing the relevance of LCE to my study where teachers use the easily available resources to mediate learning of osmosis, learners are expected to bring to school knowledge and social experience from homes, communities and diverse environments related to the topic (MoE, National Subject Policy Guide, 2009). This may improve and enhance teaching and learning as learners build on the existing knowledge. There are some researchers who possess an opposite view on the introduction of LCE into the education system. Thus, the next session discusses criticism of learner-centred education.

2.2.3.2 Challenges of Learner-Centered Education

Despite being a best teaching and learning approach, Learner-Centred Education (LCE) has been critiqued on the ground that it takes up the responsibility of the teacher in the classroom (Massouleh & Jooneghani, 2012). In his critique, Nyambe (2008) argues that LCE is affiliated to a political ideology of democracy that gives learners too much unnecessary freedom during the teaching and learning process. Nyambe (2008) argues that, although teachers' education embarked on a LCE,

teachers are still failing to implement such pedagogy and teach with a teacher-centred approach. This was later confirmed by Chaka (1997) in his study carried out in Namibia which indicates that most of the participants felt positive about LCE and optimistic about it; however, the actual implementation remained a serious challenge.

Although the NCBE is not specific about which biological concepts learners need to master, it nonetheless stresses that learners should be scientifically equipped and demonstrate the relevant skills (MoE, NCBE, 2010). Thus, in the next section I discuss osmosis in Life Science in detail as my area of focus in this study.

2.3 OSMOSIS IN LIFE SCIENCE

As already discussed in Section A, osmosis is one of the important biological concepts taught in most Biology syllabi worldwide (NSSCO Syllabus, 2010). It is also known to be a fundamental concept in understanding other life processes such as absorption/water intake in living organisms; osmoregulation and others (Ferreira & Morais, 2010; Wildenburg, 2017). Yet, it is poorly performed during the external examinations (Examiners' Report, 2009; 2016). Friedler, Amir and Tamir (1987) acknowledge that learners may often perform laboratory experiments without understanding the underlying principle of osmosis. Osmosis is known as a fundamental process to the physiology of all living things; however, its physical basis remains a challenging topic (Nelson, 2017). Oludipe (2017) further stresses that using the materials in our environments or improvised materials, may help learners to acquire knowledge and understanding of the basic science concepts and their relevance to their daily life situations. Furthermore, she indicates that to help learners understand osmosis, they need exposure to hands-on resources that give access to real life situations, for example, indigenous practices.

It is surprising that the poor performance is due to misconceptions attached to the osmosis concept. Even more, Oztas (2014) in his study conducted in Turkey revealed that secondary school learners had misconceptions about osmosis. It further noted that learners were unable to differentiate the concept of osmosis from diffusion (*ibid*.). This is similar to what I reported earlier from the NSSC Examiner's Report (2016) that Namibian learners struggle to understand and differentiate concepts, such as *osmosis* and *diffusion*. Thus, Oztas (2014) believes that such misconceptions might be due to the formal nature of the two concepts; whereby teachers need to select content materials that learners can actively manipulate and record and analyse data so that they are able to make the distinction. The

scientific inaccuracy on the conception of osmosis influences the way learners learn and the understanding of the concept (McKnight, 1993).

Some of the inaccuracies relating to the learning of osmosis were identified by Ferreira and Morais (2010:167) which may compromise the understanding of the osmosis concept and these include:

- Osmosis is only a particular case of simple diffusion;
- The phospholipid bilayer of the cell membrane is impermeable to water molecules;
- The phospholipid bilayer of the cell membrane is permeable to ions and polar molecules; and;
- The process of osmosis ends after cell is dead.

To illustrate the misconception of osmosis as per the Examiner's Reports as earlier discussed in Chapter One, the following reference is made in relation to a question in the 2018 November examination. The question was about the plant cell that was immersed in the concentrated salt solution and asked learners to explain the changes that occurred in the cell after 30 minutes. Learners showed limited knowledge in answering the question; however, the MoE, NSSCO Examiners' Report (2008:43) summarised the following as an extract:

> *Most of the candidates knew that osmosis was somehow involved, but could not explain the changes that had taken place in the cell. A shrunken or smaller vacuole means that water moves out of the vacuole and not out of the cell.* ***Candidates are also advised to describe osmosis in terms of water potential, and not in terms of high concentration and low concentration, as it is not always clear which concentration they are referring to*** *[my emphasis], e.g. the concentration of the salt, the concentration of the water or concentration of the solution.*

Based on the extract, the concept osmosis needs a thorough explanation linked to practical investigations to ensure that the meaning is well attained and understood by the learners (Akbar, 2012). He further argues that practical activities are believed to contribute to effective learning of science through observing real objects and using the theoretical aspects to make meaning of the particular concepts being studied. On the contrary, Miller (2004) sees practical activities as a waste of time and its contribution to knowledge attainment to be of less significance. Yet, for the learners to master the concepts they need to learn through hands-on, minds-on and words-on practical activities (Maselwa & Ngcoza, 2003).

2.4 HANDS-ON PRACTICAL ACTIVITIES

Practical activities refer to any teaching and learning activity which requires students to do observation or manipulation of objects and materials they are studying (Millar, 2004). Practical activities are further defined as hands-on learning activities which prompt scientific thinking about the world (SCORE, 2008). Hodson (1990) describes hands-on practical activities as useful, enjoyable and an effective form of learning in science. Practical activities are thus considered as essential part of science education by researchers, scientists, educators and learners (Akuma & Callaghan, 2016). There is also no single definition of practical activities as it depends to the individual person as they have different understandings of inquiry, so the way they view practical activities is definitely not the same (Leon, 2015). It is therefore believed that every day there is an increase in scientific knowledge and new things are being discovered (Akbar, 2012). This indicates that practical activities should be carried out in schools to foster conceptual understanding of science terminology (SCORE, 2008; Jokiranta, 2014). Furthermore, practical activities of good quality stimulate learners to actively engage in them, which may result in the development of important skills to understand scientific concepts and the process of scientific investigations (Woodley, 2009).

The inclusion of practical activities in science pedagogy involves key factors such as engaging, enthusing and inspiring learners to take up careers in science related fields (Society of Biology, 2010). Learners are expected to learn through their eyes, ears and their hands to master the science concepts (Salami & Olotu, 2014). In this case, learners may engage in various practical activities to foster productive learning. Learners in Grade 11 are expected to do both core and directly related activities. As already discussed earlier in this section, the Namibian NCBE (2010) and Biology NSSCO Syllabus (2010) aims to equip learners so that they are able to demonstrate and attain specific scientific skills (NCBE, 2010). In order to assess the attainment of scientific process skills, the following Assessment Objectives are used (NSSCO Syllabus, 2010:26), namely: knowledge with understanding, handling information, application and solving problems; and practical (experimental and investigative) skills and abilities.

Since this study is based on hands-on practical activities, I will focus more on the assessment objective C as highlighted in the NSSCO Syllabus (2010). In summary, the assessment objectives aim at requiring learners to demonstrate experimental and investigative activities which require learners to demonstrate experimental and investigative activities.

2.4.1 Benefits of practical activities

Practical activities are recognised as tools that foster learners' understanding in learning science. Thus, Maselwa and Ngcoza (2003) in their study conducted in South Africa indicate that practical activities are powerful in promoting conceptual development and understanding of science through hands-on, minds-on and words-on experiences. Woodley (2009) came to an understanding that through practical activities learners are enabled to build a bridge between what they can see and handle (hands-on) and scientific ideas that account for their observations (brain-on). Learners seem to enjoy practical activities as it adds to their motivation to study science in schools (Jokiranta, 2014). Jacob (2015) stresses the importance of practical activities in that what learners hear can easily be forgotten but what they see cannot and may last longer in their memory. Apart from being motivational and fun, practical activities also enable learners to apply and extend their knowledge and understanding of Biology in innovative investigative situations that stimulate interest and aid learning of the subject (Society of Biology, 2010). However, Hodson (1990) says practical activities are unrealistic and do not always motivate learners to learn science the best. Nevertheless, SCORE (2009) indicates that practical activities benefit teachers and learners in various ways. This means, exposing learners to practical work may lead to skills development, development of personal learning and thinking skills, experimental learning, learning in different ways and independent learning (*ibid*.).

In addition to the benefit of practical activities, Millar (2004) singled out that an "effective practical activity should entail clear learning objectives, limited number of intended learning outcomes, what students can do and what they can learn from the activity. Practical activities' effectiveness depends on *how* it is used, not *that* it is used" (p. 14). Through practical activities, teachers should help learners to observe what happened and give a reason why it happened (Waldron & Doherty, 2018). Figure 2.1 below illustrates how effective practical activities should be beneficial to learners.

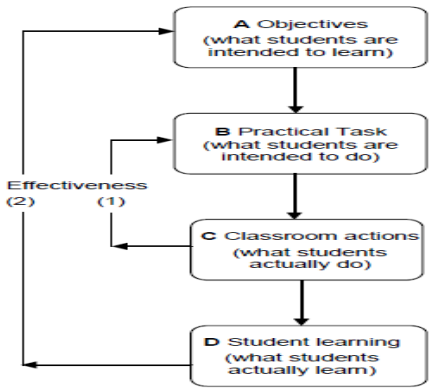


Figure 2.1: Shows the process of developing and implementing a practical task, adopted from Millar (2004, p. 14)

Based on Figure 2.1, this analytical tool indicates that each practical activity needs a clear and specific aim and objective that leads to a specific effectiveness rather than general ones (Reiss, Abrahams & Sharpe, 2012). Woodley (2009) emphasises that a good practical activity should be able to achieve its aims effectively. Hodson (1991) argues that a practical activity that lacks clear objectives becomes unproductive. The lack of clear objectives might be due to lack of proper lesson planning. As a result, Maselwa and Ngcoza (2003) propose well-planned practical activities to enhance learning of science concepts. That is, teachers should plan and design tasks that are believed to be based on desirable specific objectives of the syllabus (Miller, 2004).

Besides being a useful tool for science teaching, practical activities are also challenged in various ways. Therefore, the next section discusses the shortcomings with regard to practical activities in science teaching and learning.

2.4.2 Criticism of practical activities

There are some researchers that have expressed significant doubt about practical activities in science subjects as being ineffective (Hodson, 1991; Millar, 2004; Jokiranta, 2014; Osborne, 2015). For instance, Osborne (2015) expresses concern with the misuse and ineffectiveness of practical activities, that science is fundamentally about the idea to be tested by the experiments and development of ideas rather than the primary goal of science itself. Additionally, Osborne (2015) believes that science is distinguished by the fact that it is a set of ideas about the material world and not by empirical enquiry. Millar (2004) argues that practical activities do not seem to help learners

to learn in the way science teachers wish them to learn; and that they also waste much time and are sometimes confusing (Jokiranta, 2014). Hodson (1991) sees practical work as ill-conceived, confusing and unproductive.

To conclude this section on practical activities, the study by Mkimbili, Tiplic and Ødegaard (2017) conducted in Tanzania emphasises inquiry-based science teaching, and acknowledges that some countries, especially developing countries, are challenged by contextual factors such as large classes and lack of resources to mediate practical learning. However, it was suggested that schools with such challenges should use locally available resources to foster the learners' understanding in learning science concepts (Olasehinde, 2005; Mkimbili et al., 2017; Sabejeje, Bello, & Oloyede-Akinselure, 2017). The next section discusses the use of easily accessible resources to mediate learning.

2.5 USES OF EASILY ACCESSIBLE RESOURCES IN SCIENCE TEACHING

Easily accessible resources refer to locally available and improvised resources from the immediate environment (Asheela, 2017; Kambeyo & Ngcoza, 2017; Samuels, 2017). These resources can also be referred to as relevant and cheaply selected tools or equipment that can be alternatively used to boost the effectiveness of the teaching and learning process (Ahmed, 2008). It should be borne in mind that practical activities that require complex laboratory experiments are expensive pursuits for secondary schools (Toplis & Allen, 2012) and that most schools, especially the ones situated in rural areas cannot afford to procure them (Jacob, 2015). Salami and Olutu (2014) stress that it is of utmost importance that teachers use improvised materials in the case where scientific materials are not available or inadequate when teaching practical concepts. The findings of the study by Mensah (2015) carried out in Mexico revealed that some teachers were not using improvised resources to teach science because of insufficient in-depth knowledge on using those materials as substitutes for the standard resources. Similar cases emerged in studies conducted in Namibia by Asheela (2017) and Samuels (2017), that some teachers were not using practical activities in their science classes due to a range of constraints such as insufficient and unavailable laboratory equipment.

The National Curriculum for Basic Education (NCBE) also stresses the use of everyday materials such as waste materials that might have a scientific meaning, so that they can be used to investigate scientific phenomena (MoE, NCBE, 2010). Thus, the National Policy Guide for Natural Sciences (2009) emphasises that Biology teachers need to be creative and innovative to produce their own teaching and learning materials that are linked to the practical work intended. Hence, due to the

absence of conventional materials, efforts need to be made by Biology teachers to improve their Biology lessons by improvising teaching materials (Ahmed, 2008; Chukwuka, 2013; Mensah, 2015). However, the actual influence of these uses is yet to be determined (Chukwuka, 2013). Usage of easily accessible resources promotes understanding of the value of ordinary materials other than depending on complex laboratory equipment which are not always available (Johnson, 2000). Similarly to Millar (2004), Yitbarek (2012) confirms that practical activities that use cheap and readily available equipment enables learners to be more 'minds-on' as well as 'hands-on' when they feel they understand how the equipment they are using works. Ahmed (2008) emphasises that to teach Biology successfully even in schools with no laboratories or insufficient equipment, it would be of most significance to use easily attainable or accessible materials at the expense of the complex ones for the hands-on activities.

2.5.1 Benefits of using easily accessible resources

The advantages of using easily accessible resources is that they are cheaper, easy to use, locally available, and user friendly (Johnson, 2000; Yitbarek, 2012; Mensah, 2015). Teaching of science with locally available resources makes learning by doing accessible, even in the under resourced schools (Yitbarek, 2012). It is also believed that using the local materials when teaching science becomes more meaningful or real (Olasehinde, 2005). Salami and Olotu (2014) agree that if easily accessible materials are effectively used, learners are highly exposed to a wide range of experiences.

Besides the above, Yitbarek (2012) has faith in the use of easily accessible resources and indicates that they have the following advantages (p. 34):

- Create awareness of local available materials in own environment which stimulates creativity to use them;
- Experiments and models can be constructed without extensive experience or the self-construction develops a sense of proud ownership and promotes a more frequent use;
- The easily accessible resources need no special infrastructure neither special storage facilities;
- Leads to new knowledge discovery and talents for learners and teacher (Mensah, 2015); and
- Minimises costs on breakage, repair and loss, as they can easily be replaced due to their availability in their local environments (Mensah, 2015).

In addition to the National Curriculum for Basic Education as earlier discussed in this section, most of the science curriculum such as Physical Science, Natural Science and Health Education (NSHE), Life Science and Biology supports the use of resources found in the immediate environment when investigating, interpreting and applying knowledge to practical investigation (MoE, National Subject Policy Guide, NSHE, Life Science and Biology). There are various scholars that use the easily accessible resources in their studies in relation to teaching and learning of different science concepts. For instance, Asheela (2017) in the preparation of the traditionally brewed beverage called '*Oshikundu*' used traditional millet (*mahangu*) and sorghum (*oilyavala*) flours. After such preparation, Asheela (2017) used '*Oshikundu*' to collect the gas to test for carbon dioxide. In his study conducted in Namibia, Kambeyo (2012) used local fruits such as *ombeketo* (sour fruit), *ooshe* and other local fruits to test for acids and bases. Samuels (2017) identified easily accessible resources such as discarded electronic parts (magnets, wires and electric motors) that could be used to teach the topic of electromagnetism. Shifafure (2014) used local materials such as *Munyengo* (condenser) to distil *Kashipembe.* Even though these studies reinforce the use of easily accessible resources in teaching Science in general, I could not find any in the Namibian context that focused on osmosis concepts. Therefore, this study seeks to close the gap by exploring the use of easily accessible resources as tools for use when mediating learning of osmosis.

Besides the benefits of using easily accessible resources discussed in this section, there are some scholars that expressed the opposite views in this regard. Therefore, the next section discusses the critical views when using easily accessible resources.

2.5.2 Criticism of using easily accessible resources

To emphasise the shortcomings of the use of easily accessible resources, Akuma and Callaghan (2016) and Jacob (2015) argue that learners may develop excessive interest in easily accessible resources, rather than using the original or conventional materials. For such reasons, some resources might lack precision and accuracy in measurement or results of the investigation (Mensah, 2015; Sabejeje et al., 2017). Sometimes the easily accessible materials can be demanding and the cost involved may be more than buying the original ones (Mensah, 2015).

However, there is a need to broaden the curricula by accommodating easily accessible resources including those promoting IK and practices (Hodson, 1990). Daba, Anbassa, Oda and Degefa (2016) indicate the need for African countries to take accountability and specific action to strength science

and find solutions to their own scientific problems. This can be done through the use of some of easily accessible resources that could be in the form of cultural artefacts or tools in order to close the gap of what is usually taught in the classroom and what exists outside classrooms in society. In the next session, I discuss the use of IK in teaching science.

2.6 USES OF INDIGENOUS KNOWLEDGE IN TEACHING SCIENCE

Indigenous Knowledge (IK) refers to local knowledge embedded in cultural traditions of a specific society and involves wisdom that has been developed and passed on over generations (Kibirige & Van Rooyen, 2006). The United Nations Educational, Scientific and Cultural Organisation (2017) further defines IK with reference to understandings, skills and philosophies developed by societies in relation to the interactions with their natural settings. Asogwa, Okoye and Oni (2017) further refer to IK as a body of knowledge of what indigenous people know and do.

There are various indigenous practices that local people have that are worth incorporating into the science curriculum. In this case, Chikaire et al. (2012) refer to indigenous practice as the local actions that local people do to understand a certain phenomenon through experiencing and carrying out informal experiments resulting in the attainment of indigenous knowledge. Having diverse cultures and societies in which many indigenous people live, the education system should have a range of programmes that support the inclusion of IK (King & Schliemann, 2004). Mukwambo, Ngcoza and Chikunda (2014) support the inclusion of IK in the curricula of African Education. For instance, the study by Milne (2017) in Ontario, Canada indicates that its Ministry of Education commits to supporting and including indigenous practices in the curriculum to ensure that all learners know their cultures, histories and appropriate indigenous practices.

In some countries, indigenous knowledge is largely ignored and not recognised in both curriculum design and implementation or teaching, which creates complications for proper documentation of the IK facts (King & Schliemann, 2004). One of the participants in the study of Webb (2013) conducted in South Africa made a strong statement on IK saying that indigenous people are the pioneers and the founders of what is happening nowadays; and their myths and stories have become a way of life. Although the National Curriculum for Basic Education (2010) supports the use of the local environment for teaching science it does not clearly guide in terms of how the indigenous knowledge and practices are to be incorporated in the curriculum. However, Abah, Mashebe and Denuga (2015) condemn such unclear curricula, as it is attributed to the cultural gaps and learners' underachievement

in schools. This may create a challenge for the learners, because of the difference between daily life exposures in their local communities, to what they are expected to learn in the class.

Ogunniyi (2006) and Shizha (2015) express dismay that most African teachers lack the ideal skills and appropriate pedagogy to incorporate indigenous knowledge or at least to Africanising the curriculum to respond to the needs of the learners and make it more meaningful to their situation.

In the next section, I discuss the benefits of indigenous knowledge in teaching and learning of science.

2.6.1 Benefits of indigenous knowledge in science teaching

Various researchers have embarked on their research journey on the use of indigenous knowledge to teach science concepts, whereby some have supported the inclusion of IK due to its benefits and the contribution it may serve in science teaching and learning. Hodson (2009) indicates that indigenous knowledge is a crucial element and important for cultural stabilisation. Learners feel more comfortable and accepted when indigenous practices are incorporated in teaching and learning (Milne, 2017). Thus, integration of IK into science teaching and learning may maximise and enhance learning (Zinyeka, Onwu & Braun, 2016). The inclusion of IK practices into teaching and learning of science helps learners to understand the challenging concepts that are difficult to interpret (Lanzano, 2013). Furthermore, IK helps indigenous people to find solutions to challenges like any other practices. For instance, the indigenous practices on food processing, preservation, and storage into educational policies may lead to poverty reduction and better understanding of science concepts such as osmosis (Jacob, 2015).

For the learners to master scientific concepts, teachers may use those indigenous practices (examples) as *prior knowledge* for the learners to master them and enhance better understanding. *Prior knowledge* refers to learning experiences in relation to what learners already know before the new knowledge they get from the class (Roschelle, 1995). That is to say, meaningful learning occurs if what learners are taught in the classroom has a connection with existing knowledge (Ausebel, 1961). In agreement, Kuhlane's (2011) study in South African schools revealed that the use of prior knowledge and experiences during teaching and learning facilitate meaningful learning. In most cases, it is hard to learn and construct concepts without prior knowledge (Resnick, 1983; Roschelle, 1995). Thus, it is of the importance that when science teachers teach concepts they need to elicit and integrate prior knowledge (Kuhlane, 2011). This helps learners to relate the topic to what is happening in their daily life situation, as well as their environment.

In the next section, I discuss osmosis in indigenous practices.

2.6.2 Osmosis concepts in indigenous practices

Ferreira and Morais (2010) view osmosis as an important concept in the learning of science. They suggest that it plays a vital role in our daily life situations whereby most of life's processes taking place in our bodies use osmosis. In understanding osmosis, teachers may use various indigenous practices to demonstrate how it occurs or what might lead to osmosis taking place, to broaden the understanding of such concept (Ahmed, 2008). For instance, there are some examples by Gemma (2014) that indicate how osmosis occurs in our daily life situations which may act as prior knowledge when teachers mediate learning of osmosis using easily accessible resources. These include; "dehydration, soaking of fruits and vegetables, salting slug, how cholera occurs and water treatment" (p. 1). This suggests that osmosis is important in various processes such as preservation of foods (Asogwa, et al., 2017). Food preservation is the process of treating and handling food to stop or slow down its spoilage, making it easier to keep for longer periods of time without losing optimal nutritional values (Yadav & Agarwala, 2011).

For instance, meat can be preserved whereby salt is applied on it which creates differences in the water potential gradient (Krishnan, 2014). Then water diffuses from inside of the meat, where higher water potential is, to the outside surfaces where there is lower water potential, resulting in the water reduction in the meat (Krishnan, 2014). Reduction in water content inside the meat will also affect various biochemical and enzymatic reactions and also reduce microbial growth; avoiding the meat to be spoiled by microorganisms or without jeopardizing future consumption of food (Asogwa et al., 2017; Krishnan, 2014); so, the meat stays longer without being spoiled. This traditional practice has gained popularity in rural areas and used to perceive staple food such as grains for humans and animals (Krishnan, 2014). The decision taken to preserve food has resulted due to the lack of proper retailing and inadequate refrigerator's facilities in some countries (Yadav & Agarwala, 2011). The local fruits and vegetables that are preserved include:

Fruits: eembe (berries), eenyandi, eendunga (palm fruits), eeshe, eenghekete); and

Vegetables: ombidi (dry wild spinach), tomatoes, beans (omakunde), peas (epoke), maize (omapungu), seeds, omayangwa (pumpkins), marura fruits (eengongo), oshikapa (sweet potatoes).

Food preservation can be costly and expensive when using modern practices; whereas, it can be cheap or costless when using indigenous practices (Colon-Singh, 2016). For instance, modern preservation mostly includes freezing, vacuum drying, using a dehydrating machine, canning, pickling, smoothing, and baking. Most of the modern practices such as vacuum drying, canning and others are very expensive and not easily obtainable or accessible in some communities, and teaching of such practices can be difficult (Krishnan, 2014; Colon-Singh, 2016). In contrast, common indigenous preservation includes sun-drying, *okufumika ombelela* (rough meat cooking), *okushika omashini* (shaking milk to form sour milk) and salting the meat.

2.6.3 Criticisms on the use of Indigenous Knowledge

Although Indigenous Knowledge (IK) has gained popularity in various aspects, the lack of documentation, high illiteracy level, influences of western culture, and change in socio-cultural status among community members has affected the continuity of indigenous practices (Asogwa et al., 2017). Thus, Bohensky and Maru (2011) suggest that even though there is an increasing trend on integrating IK in the curricula, there has been little done regarding bringing IK and science together. Mukwambo (2016) opines that IK suffers from under-recognition in the teaching and learning of science as some IK has not changed even though new ideas in science have emerged and some might have even already been contaminated. Suggestively, some of the authors felt the integration of IK into the curriculum may compromise the science discipline for discovering facts through investigations and experiments (Asogwa et al., 2017; Clifton, 2017). Despites various thinking and critiques of inclusion of IK, Kaya and Seleti (2013) continue to defend indigenous knowledge and that Africans should acknowledge their indigenous knowledge as an essential part that also contributes to the global pool of knowledge rather than just enhancing or sustaining its people. In this case, Abah et al. (2015) feel that both IK and western science are complementary and may collectively form a firm ground to support teaching and learning of science in schools. In the next section, I discuss the conceptual framework and then theoretical framework respectively, as the lens that I used to analyse my data.

2.7 CONCEPTUAL FRAMEWORK

As earlier indicated, this study is informed by the key concepts of conceptions, experiences and dispositions as well as professional development. In this section I will discuss each key concept as follows.

2.7.1 Teacher's conceptions and experiences

Conceptions refer to beliefs, thoughts or ideas teachers have about teaching and learning (Hewson & Hewson, 1987; Kagan, 1992; Koç & Köybai, 2016). This is pivotal to this study because in order to understand how teachers mediate learning of osmosis using easily accessible resources, it is important first to explore their conceptions and experiences. Koç and Köybai (2016) believe that teachers' beliefs or thoughts influence the way the subject content is presented to the learners in the classroom. Moreover, the teachers' pedagogical approach and content knowledge, as well as other personal characteristics determine the type of behaviours in the class, instructional practices and the learning environment (*ibid*.). This concludes that there is a relationship between conception and the method of teaching in the classroom. Eley (2006) argues that although teachers differ on their teaching and learning practices, their conceptions should be based on their reflection on the teaching, and not directly in the teaching episodes. This also applies to the practical knowledge the teachers have, which may differ from teacher to teacher. Van Driel, Beijaard and Verloop (2001) and Lederman (1999) stress that more experienced teachers possess positive conceptions and tend to attend better to practical activities during lesson planning and teaching comparing to the novice teachers. Furthermore, Ferreira and Morais (2010) indicate that some teachers' conceptions are due to insufficient subject knowledge and skills which may result in scientific inaccuracies as earlier discussed.

The components related to teachers' conceptions or beliefs discussed in Atallah et al. (2010) can also apply to teaching Biology as a subject; which includes: belief about the subject, belief about oneself as a subject user, and the learners, and beliefs about teaching the subject. This is similarly related to this study on what teachers' conceptions are in relation to practical activities, use of easily accessible resources and indigenous knowledge (IK) to mediate the learning of osmosis. For instance, how teachers identify IK in relation to the teaching of osmosis in Biology and how beneficial it is to the learning of osmosis. Thus, Dziva, Mpofu and Kasure (2011) recognise that preconceptions (everyday

common knowledge) inhibits teaching and learning of science because it makes more sense than the concepts found in that subject.

The study by Lederman (1999) conducted in Corvallis revealed that teachers have a positive understanding that teaching science is partially based on human creativity, imagination, subjective (theory laden) and yet empirical evidence. This means that teachers have a strong commitment that science concepts are constructed based on the observation of phenomena. Lederman (1999) indicates that it is best to make use of the environment when teaching science subjects.

With reference to indigenous knowledge (IK), the study by Mushayikwa (2014), conducted in South Africa, indicates that before the intervention, about 67% of the participants perceived IK negatively and believed that it holds the African continent back, and that its integration should not be entertained. He continues that teachers perceived IK as backward to science and merely for uncivilised people, and thought that western science was special. After the intervention and working as a community of practice (CoP), most of the participants' dispositions changed from the incorrect assumption to positive thinking over IK inclusion in science teaching (*ibid*.). Thus, Eun (2008) emphasises that goal-directed activities lead to development within individuals after an intervention. Therefore, to apply such to my study, it is important to explore teachers' dispositions (Taylor & Wasicsko, 2000) towards the use of easily accessible resources to enable to design appropriate model lessons during the intervention. This means the participation in such an intervention is part of professional development that might provide teachers with new knowledge and skills to overcome their own problems during teaching and learning (Eun, 2008). Therefore, in the next section, I will discuss professional development.

2.7.2 Professional development

Professional development refers to a wide variety of specialised training where the professional learning is expected to take place to improve professional knowledge and skills of teachers (Shabani, 2016). After teachers have gone through a professional development, they need to be engaged in in-service training or interventions to boost their pedagogical approaches to teaching and learning (Shabani, 2016). Runhaar (2008) extends the definition of professional development in terms of innovative behaviours and knowledge sharing when carrying on the perceived task to reach the desired or independent goal. Although Vygotsky's theory focuses on how children learn, Eun (2008) feels that adults also learn as a result of social interactions. During the workshops in this study, as

teachers interacted with one another, they eventually learnt and improved their pedagogical approaches (Shabani, 2016).

In this case study, there was a need for intervention and support for teachers in teaching science as a practical subject (Woodley, 2009). To successfully teach science subjects, teachers are expected to internalise teaching into practical activities and relate the theory to the phenomenon that they see in experiments, that is, practice (Jokiranta, 2014). It is noted in some instances that some teachers are only concerned with finishing the syllabus and are reluctant to work in the afternoons to plan 'hands-on' activities (Ngcoza, 1998). What happens in schools is that more time is spend on the theory teaching of science and only a little time is used for hands-on components or activities (Toplis & Allen, 2012).

Teachers need to be empowered to carry out practical activities that would expand quality learning opportunities and independent learning (TALIS, 2009). The National Curriculum for Basic Education (NCBE) supports teachers by providing clear guidelines on how to ensure effective teaching and learning as earlier discussed in Chapter One. The NCBE also empowers teachers to develop teaching and learning aids that are suitable to their situations and learning environments (2010), which is not the case. Therefore, exploration on how teachers mediate learning of osmosis using easily accessible resources may support or may result in effective learning. In the next section, I discuss the theoretical framework that informed my study.

2.8 THEORETICAL FRAMEWORK

Since my study focuses on the use of easily available resources to mediate the learning of osmosis, it is appropriate to use the socio-cultural theory as a theoretical lens which emphasises that learning takes place as a result of social interactions and collaboration with others. This happened when the teachers in my study were engaged in social activities during interventions where they interacted with one another and collaborated when developing the model lessons (Amineh & Als, 2015; Wells, 1994). Therefore, this section aims to elaborate on the contribution of the socio-cultural theory to my study.

Socio-cultural theory was developed by Lev Vygotsky, a psychologist (1896-1934) who believed that society helps develop the individual and *vice versa* (Cherry, 2017; Vygotsky, 1978). Vygotsky's (1978) seminal work laid the foundation for many researches and gained popularity over the past

decades (Bunyakarte, 2010; McLeod, 2014). The socio-cultural theory was introduced in response to the behaviourist theory of John Piaget (1959) who underestimated children's abilities and depicted that learners constructed knowledge for themselves (Wood, Smith, & Grossniklau, 2001). In such instances, Vygotsky's theory (1978) extends to seeing knowledge as constructed through the social interactions of individuals and the associated society. This means that Vygotsky's socio-cultural theory differs from any other constructivist theories as it puts more emphasis on social interactions and how individual mental functions relate to cultural and historical contexts (Scott & Palincsar, 2013). With such reference, the socio-cultural theory has a wider lens for seeing how learning occurs or how knowledge is constructed due to socio-cultural interactions. Moreover, Cole and Miyake (2016), Cherry (2017) and Scott (2016) indicate that Vygotsky's socio-cultural theory extends its focus to understanding how cultural beliefs and attitudes affect the interactions rather than only focusing on individual learning. In simple terms, Pathan et al. (2018) state that Vygotsky's theory focuses on the social, cultural and historical artefacts which are important in the learners' cognitive development and learning.

Vygotsky's socio-cultural theory (1978) also emphasises how knowledge is constructed within learning environments. McRobbie and Tobin (1997) and Bunyakarte (2010) emphasise that learning takes place in various learning environments such as classrooms or anywhere that interactions take place. However, learning may be influenced constructively or constrictively by the variables that are found in such environments (McRobbie & Tobin, 1997). Hence, individuals that are found in those environments are active agents with different beliefs and dispositions (Taylor & Wasicsko, 2000), and also different socio-cultural backgrounds (McRobbie & Tobin, 1997). Nevertheless, Vygotsky (1978) believes that as soon as various tasks are introduced, learning is taking place, knowledge is assimilated and then internalised. *Internalisation* refers to a learning stage where the individual accepts the sets of norms and values that are established by others as a group or society (Vygotsky, 1978).

In conclusion, the socio-cultural theory in this study is used to look at the interactions and collaborations in social learning environments (McRobbie & Tobin, 1997). I also looked at the indigenous practices teachers may use when mediating the learning of osmosis, so that the learning content could be related to their daily life situations as an introduction to the concept of osmosis. In this case, the use of cultural practices as prior knowledge might help learners to make meaning of osmosis in relation to the content that learners are required to master as part of their specific objectives

in their syllabus (Gee, 2012). The National Curriculum for Basic Education (NCSE) also emphasises that the home and community should actively support the holistic development of the learner, which may enhance learning (MoE, NCSE, 2010)

In this study, to have a broader understanding, the next discussion focuses on one of the key concepts of Vygotsky's socio-cultural theory (1978), namely, mediation of learning.

2.8.1 Mediation of learning

Mediation involves the use of cultural tools such as language and materials to achieve the learning goal (Vygotsky, 1978). It is known to be central in learning (Shabani, 2016). To achieve the learning goal in my study, I observed two lessons in Grade 11 Biology classes looking at the interactions and the mediation processes that occurred when teachers used easily accessible resources as mediating tools to aid in the learning of osmosis. Teachers are expected to be mediators of learning for the learners to play an active role and be able to learn (Amineh & Asl, 2015). In this study, teachers used easily accessible resources and indigenous knowledge to teach osmosis.

The mediation triad linking in Figure 2.2 helped me to unpack the mediation process and the associated challenges that teachers face when mediating the learning of osmosis.

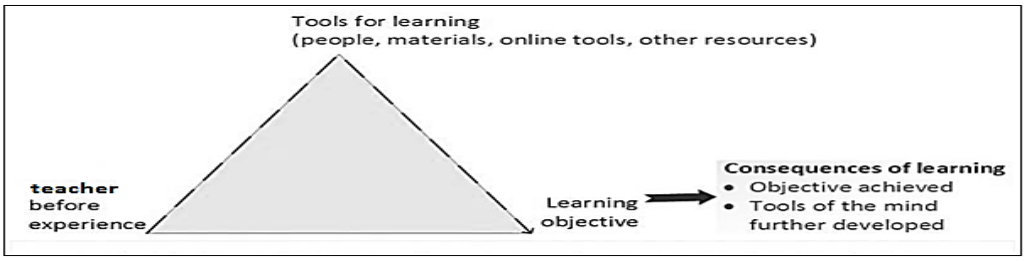


Figure 2.2: Shows mediation triad linking Adopted from Vygotsky (1978, p. 54)

Vygotsky's primary emphasis is on mediating using symbolic tools and organised learning activities that are appropriate to the context of particular sociocultural activities (Kozulin, 2003; Mavuru & Ramnarain, 2017). Kozulin et al. (2003) believe that as part of a socio-cultural theory mediation cannot properly be comprehended unless the role of the tools for mediation are acknowledged. In relating this to my study, the use of practical activities using easily accessible resources and the integration of indigenous knowledge during intervention and demonstration of model lessons acted as a tool to help teachers mediate the learning of osmosis.

2.9 CONCLUDING REMARKS

I this chapter, I firstly discussed the general view of my study. Secondly, I discussed literatures in relation to the Namibian curricula such as the National Curriculum for Basic Education (NCBE), Namibia Senior Secondary Certificate Syllabus for Biology, and Learner-Centred Education (LCE). Thirdly, I discussed the *osmosis* concept in Life Science in relation to the NSSC Syllabus of Biology, Examiner's Reports and other literatures. Fourthly, I discussed the practical activities pedagogy, whereby the discussion included the benefits and criticism of practical activities. Fifthly, I discussed the use of easily accessible resources in science teaching and learning. I then discussed the use of indigenous practices in science teaching and osmosis in particular. Thereafter, I discussed the conceptual framework with the focus on the key concepts of conception and dispositions of Biology teachers when mediating the learning of osmosis using easily accessible resources and then their professional development. Lastly, I discussed Vygotsky's socio-cultural theory (1978) as a theoretical framework that informed my study; where I focussed on the concept of mediation.

In the next chapter, I discuss the research design and methodology used to generate data for this study.

CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION

The goal of my study was to explore how Grade 11 Biology teachers mediate learning of osmosis when using easily accessible resources. In this chapter, I thus discuss the methodological overview of the qualitative research procedures used to collect, analyse and present data. The first part of this section will give a brief overview about the research design and methodology which was used in this study. The second part of this chapter discusses the information with regards to the paradigm, type of study, phases of the data collection process, sampling, data gathering techniques, data analysis procedures, validity and trustworthiness and ethical considerations. The chapter ends with concluding remarks.

3.2 RESEARCH DESIGN AND METHODOLOGY

Research design is the conceptual structure which a researcher uses to conduct a research study, data collection and analysis (Kothari, 2004). That is, the research design describes the plan or procedures used to conduct the research (McMillan & Schumacher, 2010). According to Bertram and Christiansen (2015), a research design should clearly state what the research will do with the data after the data collection. In other words, it describes what data is required, what methods are used to collect and analyse that data, what happens during the research process and how all these would answer the research question, (McMillan & Schumacher, 2010) which in this study is: how Biology grade 11 teachers mediate the learning of osmosis using easily accessible resources in the context of this study. Clark and Creswell (2015) define research methodology as a systematic way used to solve a research problem that includes *why* it has to be done that way and not in another way and *how* the research is done. In this study, the exploratory research design was employed (*ibid*.).

This study is underpinned by an interpretive paradigm that aims at understanding the nature of human experiences and individual actions (Cohen, Manion, & Morrison, 2018; McMillan & Schumacher, 2010).

3.2.1 Interpretive paradigm

Paradigms represent a key element in the research project that influence how the research should be conducted and how the meaning of reality may be constructed and interpreted (Poni, 2014). Thus, in

this study, an interpretive paradigm was used to attempt to understand and interpret the world and real practices in the classroom situation (Cohen et al., 2018). An interpretive paradigm is a framework that guides how the study should be conducted based on the epistemology and ontological world views (McMillan & Schumacher, 2010). The interpretive paradigm was deemed appropriate for my research study because it helped me to do the exploration on how Grade 11 Biology teachers mediate the learning of osmosis using easily accessible resources. This study thus used a systematic approach to identify the research problem, collect, analyse and present the data in a logical setting (McMillan & Schumacher, 2010; Richards, 2005). Within the interpretive paradigm, a qualitative case study approach was adopted.

3.2.2 Qualitative case study

Qualitative research is the type of social science research that collects non-numerical data and is intended to collect and interpret the meaning from the data which helps a researcher to understand the social life of the targeted participants (Crossman, 2018). Qualitative research has the advantage of providing detailed data, encouraging discussion and being more flexible. Yet, it is criticised on the basis of using only a small number of participants, which makes it difficult to generalise data and lacks anonymity (Mander, 2017). In this study, I thus adopted a case study approach. A case study is a systematic and in-depth study of a particular case in its context (Cohen et al., 2018; McLeod, 2008; McMillan & Schumacher, 2010; Rule & John, 2011). As an empirical enquiry, a case study enables the researcher to examine the data in a specific context in a real-life situation (Zainal, 2007). Case studies do not only help to explore or describe the data in real-life environments, but also help to explain the complexities of real life situations which may not be captured through experimental or survey research (Zainal, 2007). My study examined a case of two teachers who mediated learning of osmosis using easily accessible resources in Biology Grade 11 classes in Oshikoto Region.

I decided to use a case study to get in-depth information or analysis (Cohen et al., 2018; McMillan & Schumacher, 2010) of how teachers mediate learning of osmosis when using easily accessible resources.

Case studies have been criticised by other researchers on the basis that they influence the direction of the findings, which may result in biased views or conclusions and also for shortage of a well-defined structure or protocol (Yin, 1994; 2002). The case study requires much time to be conducted and may produce massive documentation (Yin, 2002). Case studies depend only on a single case,

which makes it difficult to generalise data (Tellis, 1997). Wills (2014) on the other hand sees the criticism of generalisability as of little relevance when the intention is on a particular situation.

In summary, a qualitative case study refers to "an intensive, holistic description and analysis of a bounded phenomenon such as a programme, an institution, a person, a process" and so on (Yazan, 2015, p. 139).

3.2.3 Research goal and questions

The main goal of this study was to explore how Grade 11 Biology teachers mediate learning of osmosis using easily accessible resources.

To achieve the goal of this study, the following research questions were addressed:

1. What are the Grade 11 Biology teachers' experiences, conceptions and dispositions towards the use of easily accessible resources when mediating learning of osmosis?
2. What are the enablers or constraints that Grade 11 Biology teachers encounter when developing model lessons on osmosis?
3. How do Grade 11 Biology teachers mediate learning of osmosis when using easily accessible resources?

3.2.4 Research site and participants

This study started with four Biology teachers that were conveniently selected to take part in semi-structured interviews (Phase 1) to obtain data on their experiences, conceptions and dispositions on how they mediate learning of osmosis using easily accessible resources. After the semi-structured interviews, three teachers volunteered to participate in the three workshops (Phase 2). Afterwards, only two teachers were observed when teaching the model lessons that we co-developed (Phase 3).

For Phase 3, this study was conducted in two selected secondary schools in the Oshikoto region (as pointed in the map below), which is on the northern side of Namibia, i.e. Champion Secondary School, and the other one Brave Secondary School (both pseudonyms). Champion SS has the population of about 500 learners and it is a boarding school (government hostel). The teacher to learner ratio for that school is 1:30, whereas Brave SS has 365 learners and it is a non-boarding school, and the teacher to learner ratio is 1:30. Figure 3.1 below shows the Namibian map with the regions.

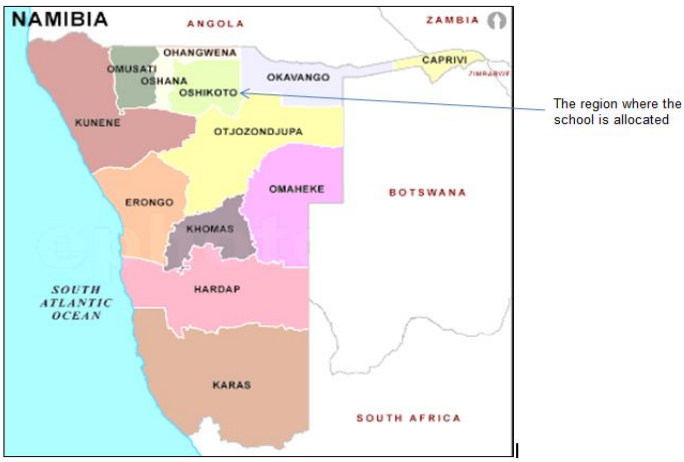


Figure 3.1: Namibian map (https://www.google.com/search)

I conveniently selected these schools so that I could easily access them (McMillan & Schumacher, 2010). To be able to gain an in-depth exploration and a manageable number of participants, I only focused on three teachers that volunteered to attend the workshop on the use of easily accessible resources (Bertram & Christiansen, 2015). My initial plan was to select only two teachers, but as a result one teacher volunteered to be part of workshop. The initial selection of teachers was based on the outcome of the interviews (responses) from their semi-structured interviews to ensure good presentation and ensure that teachers that had little exposure to the use of easily accessible resources or hands-on activities were catered for. The reason for doing this was to provide professional support on the use of easily accessible resources during the workshop and learn from one another through social interactions as espoused by Vygotsky (1978).

Another selection criterion was that a teacher should be teaching Biology in Grade 11 in 2018. The reason for selecting Grade 11 Biology teachers only was that, according to the NSSC Biology syllabus (2010), the topic on osmosis is taught in this grade although it is only assessed at the end of Grade 12. The teachers that volunteered both met the selection criteria, as they both teach Grade 11.

The table below shows that all four teachers (T1-T4) who participated in this study qualified to teach at the secondary level Grade 8-12 and were all at the time of the study teaching Grade 11. Three of the participants hold a Bachelor of Education and the other participant holds a Diploma in Education (Secondary Level). Both participants majored in Biology and their teaching experiences varied and ranged from 3 years to 8 years.

Table 3.1 1: Shows Participants' Profiles from the Interviews

Teacher Code	**Qualifications**	**Teaching experience**	**Years of Biology teaching**	**Grade taught currently**	**Subject currently taught**	**School Name (pseudonym)**
T1	Diploma in Education (Secondary Level): Biology & Physical Science	9 years	3 years	10, 11 & 12	Biology; Physical Science	Brave SS
T2	Bachelor of Education (Bed): Biology & Geography	8 years	8 years	9, 10, 11 &12	Biology; Life Science	Champion SS
T3	Bachelor of Education (Bed): Biology	3 years	3 years	8, 11 & 12	Biology; Life Science	Champion SS
T4	Bachelor of Education (Bed): Biology	5 years	5 years	11 & 12	Biology; Life Science	School C SS

Next, I discuss how the data were gathered using different research techniques to find answers to my research questions.

3.3 DATA GATHERING TECHNIQUES

In this case study, data sets were gathered using a variety of data collection techniques (McLeod, 2008; Cohen et al., 2018) such as semi-structured interviews, workshop discussions, observations (videotaped lessons) and stimulated recall interviews (SRIs). Table 3.2 provides the summary of the data gathering techniques. Each data gathering technique will be discussed below.

Table 3.2: Data gathering techniques

Phases	**Data collection method**	**Data to be gathered**	**Purpose**	**Research question**
Phase 1	Semi-structured interview	Teachers' experience, conception and dispositions	To get data on the teachers' experiences, conceptions and dispositions on how they mediate learning of osmosis using easily accessible resources. The semi-structured interview questions will be pre-tested to test the appropriateness of them.	1
Phase 2	Intervention (workshop discussions)	Contributing factors that influence teachers when developing the model lessons (different phases were employed)	To expose teachers to practical activities using easily accessible resources when mediating the learning of osmosis; To co-plan and co-develop model lesson, that each teacher will implement at own class; To reflect on the implementation process.	2
Phase 3	Observation	The use of easily accessible resources during lessons. Mediation of learning during interactions	Observe model lessons for two teachers, on how they use easily accessible resources when mediating the learning of osmosis. Three lessons for each teacher. Observe social interactions in each classroom as a social learning environment. All lessons were video recorded.	3
	Stimulated video recall interviews (SRI) and Reflections	observe what happen during mediation process, analyse the action, Reflection of the mediation process	To validate data and clear out some misunderstanding or contradictions during mediation of learning process. Teachers to reflect on their own teaching practices. Give me an insight of whether or not the workshop has impacted on their teaching.	3

3.3.1 Semi-structured interviews

An interview is a conversation between the researcher and participants (Bertram & Christiansen, 2015; Fylan, 2005). Semi-structured interviews were used whereby a list of questions was developed to guide the type of data intended to be obtained (Bryman et al., 2017). Semi-structured interviews as a flexible approach were used to collect baseline data in this study (Cohen et al., 2018). This type of interview was used as an in-depth approach to explore and gain insight into teachers' experiences,

conceptions and attitudes towards the use of easily accessible resources when mediating learning of osmosis (McMillan & Schumacher, 2010). I chose an interview method as it allowed me to probe for clarifications (Bertram & Christiansen, 2015). Ou and Dumay (2011) understand interviews as a social platform, instead of treating it as only a tool for collecting data.

I used the interview guide with key open-ended questions that helped me to answer my research question 1 (Van Teijlingen, 2014) (see Appendix 14). For data validity purposes and rectification of errors, I piloted my interview schedule with one of my MEd colleagues and further discussed it with my supervisors. The reason for piloting was to test how appropriate the interview questions were, increasing its validity, before data collection commenced (Brooks, Reed & Savage, 2016; Dikko, 2016; van Teijlingen, 2014). The piloting helped me to make adjustments to my questions and I was able to collect the data that I intended to obtain within the desired time.

I interviewed four Biology Grade 11 teachers individually from three different schools. The interviews took place at the schools' premises after school hours. The sites were chosen carefully to provide for a convenient, comfortable and safe environment where the participants could relax and speak openly on the questions asked (Fylan, 2005). In my study, interview duration differed from participant to participant, but ranged from 15 to 20 minutes. The interviews with all the four Biology teachers took three days, because I could only afford to visit one school each day. Interviews were recorded and transcribed thereafter.

I found semi-structured interviews very useful and beneficial because it enabled me to find answers to research question 1. Generally, interviews went very well, and teachers were free with their answers. The only challenge that I found during the interviews was that some teachers struggled to answer some of the questions as I expected. The challenge could be that perhaps some questions were not clear to them or ideally, they needed time to think about them first.

3.3.2 Workshop discussions

The workshops were part of an intervention intended to support teachers' understanding, knowledge and skills on how to mediate the learning of osmosis using easily accessible resources (DeMonte, 2013). Ngcoza (2015) indicates that the engagement of teachers in an intervention may generate remarkable results. During workshops, we engaged in different discussions and activities using easily accessible resources on osmosis and then co-planned and co-developed two model lessons that they later implemented in their own classes (see Appendix 20). Most of the activities during the workshops

were discussed in detail under the research process (with research phases). The workshop went well, because the participants were active enough and excited to be part of the demonstrations of the tasks during the workshops. One of the challenges I had was that I had to transport one of the teachers from their school to the workshops, as schools were not in the same district. Moreover, time was not always on my side because the workshops always took place after school, and I had to first wait for all the teachers to finish their school work before joining me for the workshops. This shortened the discussions during the workshops, and activities were done in a rush. Another challenge I also noticed was that teachers were tired at one point as they had been busy with their learners and school activities. Nevertheless, I succeeded in working with them, and received their co-operation. After the co-planning and the development of model lessons, the implementation started, thus the next section discusses the process of observation in the classrooms.

3.3.3 Observations

My observation mainly focused on two teachers while teaching the model lessons on osmosis using easily accessible resources to gain rich and deeper insights (McMillan & Schumacher, 2010; MacDonald, 2012). The third teacher teaches at the same school with one of the other teachers and was used as a critical friend. I observed four lessons in total – two lessons per teacher **(**see Appendix 12**).** Observation helped me to gain first-hand information of what really happened in the classroom (Bertram & Christiansen, 2015).

Like any other data collection techniques, observation has its own advantages as well as shortcomings. Kawulich (2005) indicates that generally, the challenge with observation is that sometimes the participants do more or maybe slacken off when they know that they are being observed, which is known as a Hawthorne Effect. To reduce such an effect, I observed teachers more than once which helped me to gain accurate data (Borner, 2012). Lessons were videotaped by my critical friend so that I could focus mainly on the observations and taking of field notes. In the first lesson, learners reacted differently and looked excited about the recording, because they could see themselves. This was a challenge and I realised that I should have piloted the lessons before the actual data collection so that learners would then be used to the video recording. This realisation was confirmed when in the second lesson, learners calmed down and seemed to be used to being recorded. After the lessons, stimulated recall interviews were conducted.

3.3.4 Stimulated recall interviews

A stimulated recall interview (SRI) is a collaborative inquiry between teachers and researcher with the dialogue focused on the practice by the video or audio recall (Lyle, 2003; Nguyane, McFadden, Tangen, & Beutel, 2013). Stimulated recall interviews are known to have a potential strength as a clear professional development tool, whereby teachers can critically reflect to understand their own teaching practice (Reitano, 2005). After every lesson, together with each teacher, we reviewed the video and critically reflected on what happened during the lesson (Nguyane et al., 2013). I chose this method because, it helped me to identify and examine teachers' thoughts, decisions and reasons for acting (Reitano, 2005). The SRI also helped me to rectify and follow-up on some of the aspects that could not be well captured during the observations (Nguyane et al., 2013).

The stimulated recall interviews (see Appendix 23) took up much time, because we watched the videos first, and asked questions only during the second review of the videos. The discussions were always done after school, and sometimes teachers also had other responsibilities after school such as study supervision.

3.4 RESEARCH PROCESS

My study was conducted in ***four phases*** as follows:

Phase 1: I conducted semi-structured interviews with four Grade 11 Biology teachers to find out their experiences, conceptions and attitudes towards the use of easily accessible resources when mediating learning of osmosis. This was done to gain some insight into what was already available or known by teachers, before the actual project started. This determined how much was needed during the intervention.

Phase 2: In this stage I focused on the workshop which was conducted in different phases, as per the workshop schedule (Appendix 15). Workshops conducted were as follows:

Workshop 1: Orientation workshop: in this workshop I orientated the participants about my study and its purpose. We also analysed the biology syllabus to find out what the syllabus says about the use of easily accessible resources for practical activities in Biology. Further analysis of the syllabus was based on the concept of osmosis to find out what it says about osmosis; and also looked at how the suggested practical activities may facilitate or constrain the learning of osmosis.

Workshop 2: During workshop 2, I demonstrated some practical activities on the use of easily accessible resources when teaching osmosis. As part of these activities using easily accessible resources, in our discussion we also integrated indigenous knowledge and practices into the learning of osmosis.

Workshop 3: After the practical demonstrations, the co-planning and co-development of two model lessons were done. Participants decided on planning only two model lessons that each teacher would demonstrate in their own classes. Lesson plans and materials were prepared including the learners' worksheets. I invited a critical friend to video record so that I could focus on the workshop discussions.

Phase 3: After the workshops, two teachers implemented the model lessons in their own classrooms as planned while I observed them. Additionally, a critical friend videotaped the lessons so that I could focus on the observations. After lesson observations, stimulated recall interviews were conducted.

Phase 4: Stimulated recall interviews were conducted with the teachers after viewing the videotaped lessons.

3.5 DATA ANALYSIS

Qualitative data analysis is a systematic process of coding, categorising and interpreting data to provide explanations of a single phenomenon of interest (McMillan & Schumacher, 2010). It simply means organising what was said, heard, read or documented to make sense of it (Bodner & Orgill, 2007). As a qualitative study, I inductively analysed my data by organising it through coding, categorising into categories and sub-categories and then forming themes and patterns (McMillan & Schumacher, 2010). To do this, I adopted the streamlined code-to-theory model by Bogdan and Biklen (2007, p. 12) as shown in Figure 3.2 below.

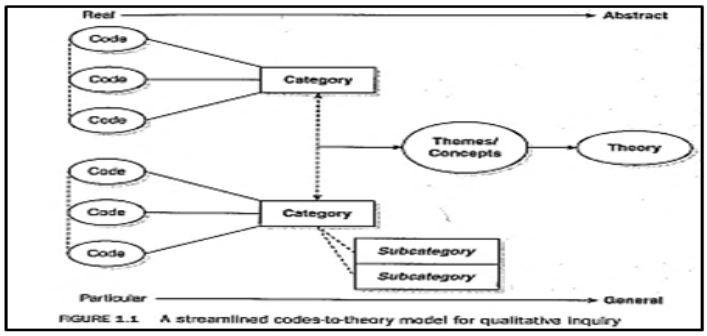


Figure 3.2: Shows codes-to-theory model (from Bogdan & Biklen, 2007, p. 12)

To add value to the organisation of data, the responses from interviews were coded to make meaning of the data; whereby the similar data were given the same colour. Afterwards, the data were categorised, and common categories were grouped into themes.

To analyse my data I employed different analytical tools that I adapted to help me to answer my research questions. To find answers to my research question 1, for instance, an analytical tool on the conceptions, experiences and attitudes with indicators, was adapted from Atallah et al. (2010). I found such frameworks useful and they provided a suitable ground to understand and gain insight into the teachers' conceptions, experiences and attitudes towards the use of easily accessible resources when mediating the learning of osmosis.

Table 3.3: Analytical Tool 1: conceptions, experiences and attitudes (adapted from Atallah et al. 2010, p. 3-4)

Concepts	**Indicators**	**Research instrument**	**Research question**
Conception and experience	• Describing the term practical activities • Describing the purpose of practical activities in Biology • Describing with broader understanding the concept osmosis • Describing what is required to teach osmosis • Describing the use of easily accessible resources when mediating learning of osmosis • Describing what in-class activities help one to teach osmosis	Semi-structured interviews	1

Dispositions	• Describing one's feelings on incorporating hands-on practical activities in science teaching • Describing one's attitudes towards scientific inquiry in Biology teaching. • Describing one's sentiment/feelings teaching practical concepts such osmosis in the under-resourced schools • Describing one's disposition towards teaching the concept osmosis using easily accessible resources • Describe the perceived value of using easily accessible resources when mediating learning of osmosis • Describing the perceived value or relevance of the topic osmosis to the world views.	Semi-structured interviews	1

From the theoretical perspective, to make meaning of my data I used Vygotsky's (1978) socio-cultural theory focusing on the main key concept of the Zone of Proximal Development and mediation of learning as a theoretical lens for my study (guided by these concepts, I focused more on the concept of social interactions, internalisation, and mediation). Within each of those concepts, there are indicators highlighting what I wanted to focus on during the data collection and analysis process. As this study involved intervention as part of professional development, I used the analytical tool that I adapted from Eun (2008) with a Vygotskian theoretical framework. This source was adapted because it helped to unpack what happened during the intervention and implementation of the developed model lessons.

In order to answer my research questions 2 and 3, I adapted an analytical tool within the Vygotskian framework by Eun (2008) based on professional development.

Table 3.4: Professional development (adapted from Eun, 2008, p.144)

Key theoretical Concept	**Related professional development practices**	**Indicators**	**Research data collection technique**	**Research question**
Social interactions	Intervention (workshop, meetings)	• Describe learning during workshop; • Describing the collaboration among participants.	Workshop discussions (interventions)	2
Internalisation	Model lessons (co-planning)	• Describing how the joint activity promotes internalization; • Describing the mastering of the concept osmosis with reference to the use of easily accessible resources	Workshops; Meetings	2
Mediation	Cultural Tools (easily accessible resources; professional networks)	• Describing the use of easily accessible resources on practical activities; • Analysing the value of using easily accessible resources during mediation process; • The co-operative learning in the classroom	Observation	2 & 3

In the next section, I discuss the procedures that I followed to ensure the quality of my study and how I maintained the validity and trustworthiness of the data.

3.6 VALIDITY AND TRUSTWORTHINESS

Validity is defined as a term used to signify research integrity and deals with how real, how authentic, and how truthful the research is (Bryman et al., 2017; Pine, 2017). To address the validity in my study, I looked at data collection techniques and analysis (Bertram & Christiansen, 2015). I used a variety of data collection methods, namely, semi-structured interviews, workshop discussions, observations and stimulated recall interviews to ensure triangulation (Bertram & Christiansen, 2015). Maxwell (1996) states that triangulation reduces cases relating to prejudice, as the data comes from different sources. Research methods and instruments being different in nature, the weakness of one method can be compensated by the strengths of another (Holtzhausen, 2001).

I used different methods to capture data from different perspectives. For instance, during lesson observations, I observed the social interactions during the mediation process using easily accessible resources; yet, this method alone would not be able to give an actual reason or clear indication for any action happening in the classroom, whereas an interview where the researcher can probe would be able to (Bertram & Christiansen, 2015). We also practiced during the contact session as guided by our supervisor, on how to go about conducting the interviews with our classmates using the interview schedule. This also helped me to validate my research instruments. To improve the appropriateness of my research methods and techniques, I first piloted the interview questions as soon as the ethical application was approved, before the data collection process commenced. Piloting involves stimulating the formal data collection process on a small scale to identify problems or detect errors in the data collection methods or instruments and rectify them (Hurst et al., 2015).

In this study, the interviews, workshops and observations were video recorded to allow for easy transcription, and for the participants to review and reflect on their lessons which may validate the data. After transcription, the transcripts were given back to the participants to check if they constituted the actual discussions, which is known as member checking (McMillan & Schumacher, 2010; Cohen et al., 2018). Participants were able to point out any incorrect concepts or meanings given during the interviews, and the errors were then rectified. I ensured that the research process was transparent with enough details aiming to reach similar conclusions (Bertram & Christiansen, 2015). To increase the validity of my study, different literatures were used to set the study context, incorporating what other researchers had found on my topic (osmosis) and the use of easily accessible resources (Bertram & Christiansen, 2015). In the next section, I discuss ethical considerations and ethical aspects relevant to this study.

3.7 ETHICAL CONSIDERATIONS

This section highlights how the research supports the ethical principles underlying this study. Research ethics refers to all values that ought to inform the work of a researcher (Coe et al., 2017). These values can be epistemic (as this research aimed at producing knowledge, thus the researcher should be committed to the honesty of what was discovered and disseminate the knowledge), and practical – the goal of the research should serve the public or improve education (Coe et al., 2017). The following are particular considerations that I took into account when dealing with the ethics underlying the study (see Appendices 1-9).

3.7.1 Respect and dignity

This research strived for honesty in all communications and practices without deceiving participants. The participants and schools were given pseudonyms to protect their identities. This also helped with anonymity and confidentiality. The consent and permission forms for this study clearly indicated all the ethical issues underlying the research. For instance, the consent letters clearly informed the participants that lesson observations needed to be video recorded. The issue with regards to voluntarily participation and the right to withdraw or demand the evidence be destroyed without any penalty were clearly explained to the participants. As a Subject Advisor, I have explained all ethics involved in the research process and the issue with power imbalances and the establishment of practice relationships were addressed prior to the commencement of research activities (Gills & Jackson, 2002).

3.7.2 Transparency and honesty

The permission for this research, an Ethical Clearance letter, was first obtained from Rhodes University's High Degree Committee. The permission was also granted from the Director of Education: Oshikoto Region, to conduct my research in the selected schools in the region. Letters were written to the Inspectors of Education (selected circuits) and to the selected schools to get permission and consents from the participants. Although my study concentrated on teachers, I also seek consent from learners and their parents since I will video record the lessons, of which the learners are a part. All letters highlighted ethical issues such as deception, confidentiality, anonymity, privacy and caring (McMillan & Schumacher, 2010). Participants were requested to sign the Consent Letters indicated that they understood and agreed with the terms and conditions of the research. Permission letters and Consent Forms formed part of research appendices. The development of model lessons was open to suggestions and was amended by the participants without being dominated by the researcher (Bowen, 2009; MacDonald, 2012). I piloted the appropriateness of my semi-structured interview questions with my Rhodes University teammate which added value to my study.

3.7.3 Accountability and responsibility

The research was contacted in accordance with research's code of ethics of the research and the one in the educational sector. I got written concerned consents from the teachers before the commencement of the data collection. In case of the learners (minors - under the age of 18), I got written consents from their parents. I also made sure that, I paid special attention to the vulnerable

participants or other circumstances that may limit the extent to which they understand their voluntary participation and role.

3.7.4 Integrity, academic professionalism and researcher positionality

I have adhered to the highest standards of academic integrity in my study and reported the actual findings of the study. Others' people work was also acknowledged as per university referencing requirements. This is my own work and did not obtain any unethical assistance or favour during my study. This study conducted in such way that, it is free from or explicitly discloses any political, racial, gathered, religious or other bias (David & Resnik, 2015).

3.7.5 Positionality

As a Subject Advisor I acknowledge the quote by Foote and Bartell (2011) which says:

> *The positionality that researchers bring to their work, and the personal experience throughout which positionality is shaped, may influence what researchers may bring to research encounters, their choices of process, and their interpretation of outcomes. (p. 46)*

As evidenced in the above quote, positionality is a practice of researcher delineating own position in relation to the study and the way data is being collected, analysed and interpreted (Qin, 2016). The issue of positionality was also addressed at lengthy with the participants in this study, so that my position as a Subject Advisor could not influence the purpose and the outcome of the study. To overcome such challenge, I first organised a meeting with the participants and briefed them clearly about my study and the ethical issues involved before the commencement of the data collection process. After discussion, I wrote letters to participants requesting them to participate in the research. During the orientation workshop the issue of ethics underlying this study and the Positionality as a Subject Advisor were discussed.

I have encouraged for the freely or voluntary participation and informed the participants that they had the right to withdraw from the research at any time with or without providing any reasons. I created platforms for discussion during workshops and observation, where participants could also take ownership in the study and free contributing. This means, the study was conducted in accordance with the Rhodes University codes of ethics of conducting research.

The challenge that I experienced as researcher was that, it took time for the participants to understand the purpose of my study. So, I had built trust through several engagements so that they can be comfortable. Although the obtaining permissions was challenging because I have to take letters for requesting the permission myself from office to office; I managed and started well with the data collection process. The Ethical consideration forms the part of Appendix L.

3.8 CONCLUDING REMARKS

In this chapter, I discussed the research design and methodology employed in this study. Firstly, I discussed the interpretive paradigm underpinning the study, followed by the qualitative case study approach, phases of the study, research sites and participants, data gathering techniques (methods), data analysis, validity and trustworthiness and ethical considerations.

In the next section, I present, analyse and discuss the research findings of the semi-structured interviews.

CHAPTER FOUR: DATA ANALYSIS, PRESENTATION AND DISCUSSION (PHASE 1)

4.1 INTRODUCTION

The goal of my study was to explore how Grade 11 Biology teachers mediate learning of osmosis when using easily accessible resources. In the previous chapter, I presented the research design and methodology underpinning this study. In this chapter, I thus present, analyse and discuss data generated from semi-structured interviews from four Grade 11 Biology teachers from three secondary schools in the Oshikoto region to answer my research question 1:

- What are the grade 11 Biology teachers' experiences, conceptions and dispositions towards the use of easily accessible resources when mediating learning of osmosis?

4.2 DATA PRESENTATION AND DISCUSSION FROM SEMI-STRUCTURED INTERVIEWS

The qualitative data I present in this section was gathered using semi-structured interviews from four Grade 11 Biology teachers. These teachers were teaching at three different schools in the Oshikoto region. The semi-structured interviews took place after school hours on the school premises to avoid interrupting the teachers' teaching time. The duration of the interviews differed from teacher to teacher and ranged between 15 to 20 minutes.

My assumption for the length of the interviews was that this could be attributed to the fact some teachers were either interested in the discussions or were keen to explore how to integrate indigenous knowledge when mediating learning of osmosis is. To protect the participants' identities, I coded teachers as follows: Teacher 1 (T1), Teacher 2 (T2), Teacher 3 (T3) and Teacher 4 (T4). The semi-structured interviews were videotaped and transcribed verbatim thereafter.

After transcription of interviews, I analysed their responses, and colour coded the matching ideas with the same colour (see Appendix 14). This led me to the formation of the categories (See Appendix 11). Thereafter, I combined similar categories to form sub-themes, and then I combined similar sub-themes to form the themes. Themes were then discussed in relation to theory and/or literature as highlighted in the Table 4.1 below. The data were organised using the streamlined code-to-theory model by Bogdan and Biklen (2007) (see Appendix 13).

Table 4.1: The emerging themes linked to the theory

Sub-themes	Theme	Theory	
		Literature	**Conceptual/ theoretical framework**
Hands-on activities require a use of process skills to master the content, bring reality and improve performance Putting what is learnt in the class into practice Putting the theory in to practice	**Hands-on practical activities help to foster learning and process skills**	Millar (2004, 2007); Maselwa & Ngcoza (2003); Jokiranta (2014); SCORE (2008); Osborne (2015); Asheela (2017); Hodson (1991); (MoE, Examiner's reports (2007-2017).	Vygotsky (1978); Atallah (2010); McRobbie & Tobin (1997)
Conception and disposition towards practical activities: Learn best when exposed to hands-on activities Feeling positive about hands-on activities as learner' learn best and improve Hands-on motivates learners to learn **Conception and disposition towards teaching osmosis** Feeling good teaching osmosis because it's fun and easy even in under-resourced schools (T1, T3). Osmosis is challenging to teach in schools where no resources are available; Osmosis concept gives broader understanding on career related information (such as farmers)	**Teachers conception and dispositions on incorporation of hands-on activities into teaching** **Teachers conception and disposition towards teaching osmosis using easily accessible resources**	Millar (2004, 2007); Maselwa & Ngcoza (2003); Asheela (2017); Salami & Olutu (2014); MoE, LCE (2003).	Atallah, 2010; Shabani (2016); Eun (2008).
Teachers' experience on hands-on activities Use of home and school-based experiments or hands-on activities to teach the topic	**Teachers' experiences on teaching using hands-on activities**	Kuhlane (2011); Rodrigo, et al. (2013); Oludipe (2017); Maselwa & Ngcoza (2003); Kambeyo & Ngcoza (2017); Milne (2017);	Lederman (1999); Vygotsky (1978); McRobbie & Tobin (1997).

Teach alternatively to practical, and summarise the possible results Used prior knowledge to enhance learning **Teachers experience in teaching osmosis** Carry out hands-on activities about osmosis Give detailed definitions Use different resources to teach osmosis	**Teachers' experiences on teaching osmosis using easily accessible resources** ○ Use of prior knowledge to teach science	Oztas (2014); McKnight (1993); Milne (2017); MoE, LCE (2003).	
Use of easily available resources when mediating learning of osmosis	○ The use of easily accessible resources enhance learning	Asheela (2017); Kambeyo & Ngcoza (2017); Samuel (2017).	
Handing of materials is a challenge Inadequate materials to carry hands-on activities Misconceptions on the topic osmosis	**Perceived challenges carrying out hands-on activities in schools** ○ Insufficient knowledge and resources to mediate learning ○ Misconceptions about osmosis	Asheela (2017); MoE, Examiners report (2017).	

I now discuss the themes that emerged from the semi-structured interviews.

4.2.1 Hands-on practical activities help to foster learning and process skills

The findings of this study revealed that teachers have different understandings on hands-on practical activities and the way they approach them.

For instance, teachers understood these as follows:

> *Practical activities I believe are activities that … help learners to apply hands-on or mind-on.* (T1)
>
> *Whereby they have to use the process skills they have learnt; … to practice what they [learners] learn during the lesson.* (T2)

> *These are activities which require experiments. They require learners to do or learn by doing this.* (T4)
>
> *Practical activities are of … are those activities that are hands-on; things that would do or activities that require hands-on or coming up with practicals that require touching or just hands on-activities.* (T3)

Based on these excerpts, it could be argued that these teachers had indeed different understandings about hands-on practical activities. However, their definitions had something in common as they all referred to practical activities as hands-on, learning by doing or touching, practicing what is learnt, and experimenting. This is in line with the findings of Miller (2004) who also indicates that there is no single definition of practical activity because they are viewed from different perspectives. Further, Leon (2015) indicates that teachers may not have the same understanding of inquiry, so their understanding on practical activities should not be expected to be the same. From this one can conclude that practical activity is a broad term which is prone to various interpretations.

The teachers also indicated that hands-on practical activities make learning of scientific concepts easy and more understandable. This is in line with the findings of the study by Maselwa and Ngcoza (2003) who believe that to master the science concepts, learners should learn through hands-on, minds-on and words-on practical activities as tools to foster understanding in the learning of science. In support, Jacob (2015) raises a strong point that, what is seen cannot be forgotten and it stays longer in the memory. To this end, T1 commented that *"Learners learn best when they are exposed to materials by feeling or touching them*".

T2 and T3 also expressed that when one is touching things or learn by doing, the mind learns better and this improves understanding. This finding correlates with the idea by Salami and Olutu (2014) who believe that learners are expected to learn through their senses to enable them to master scientific concepts easily.

On a different note, some of the teachers viewed practical activities as physical activities that help learners to master the content. According to these teachers, hands-on practical activities enhanced learning; as a consequence, learners mastered the content for the specific concept. For instance, T1 expressed that "*practical activities help learners to master their contents of whatever specific topic they are doing"* (T1). This suggests that learners need to do hands-on practical activities whereby they are afforded an opportunity to learn by doing. This is in the line with the learner-centred

approach which emphasises that learners should be central in the learning process (MoE, LCE, 2003) and learn more as they interact in social environments (Vygotsky, 1978).

The teachers who participated in this study viewed practical activities as activities where the theory needed to be put into practice. It is against this background that T4 argued that: "*Sometimes when teaching learners the theory … [they] would not really get what you are talking about; but when you are putting in into practical … they tend to know what is that you are talking about*".

Notwithstanding, these teachers indicated that there are some cases whereby a teacher might teach only theory but provide practical guidelines that could be useful to the learners in understanding the specific concept. The reasons for such an incident varied from teacher to teacher; but in most cases were due to insufficient or unavailability of resources to conduct the hands-on practical activities. In the next section, I discuss teachers' conceptions and dispositions on the use of hands-on activities.

4.2.2 Teachers' conceptions, dispositions and challenges on the use of hands-on practical activities during teaching

In response to the questions that intended to explore teachers' conceptions and dispositions on the use of hands-on practical activities when teaching Biology, they seemed to be positive about this. For example, teachers indicated that:

> *It helps, you learnt best when you are exposed to materials by feeling or touching. So, exposing learners to these materials may not be … may not be very convenient with all the learners, but it really helps for them to apply hands-on approach.* (T1)

> *I feel … learners should do more practical work [there are] some of the learners learn best or well when they ... see what happen.* (T2)

> *It is such a nice feeling, because when you are including or incorporating hands on activities, learners tend to know much better; because when practicals bring reality in the classroom… they have interest in touching things around them ... and when you are touching, your mind learns better, and if the learners practice and learn better, then at the end of the day, learners are getting marks.* (T3)

However, it appeared that they differed in expression on how they perceived the administering of the hands-on practical activities. I also found out that the views demonstrated by teachers in this study towards the hands-on practical activities depended on their interests. Therefore, the teachers' ability to teach was dependent on their dispositions and their use of resources to mediate learning of scientific concepts (Atallah et al., 2010).

For example, teachers regarded the use of hands-on practical activities as promoting sense making, interest and also improving performance. Regarding enhancement of learning, these teachers believed that as learners are exposed to the use of hands-on practical activities they tended to learn well. This suggests that learners learn best when exposed to hands-on practical activities. This finding corroborates with Salami and Olutu's (2014) findings that learners learn well when they explore materials during the practical activities and use their senses to make meaning of what they are learning. In consequence, T4 felt that when you teach learners theory it is important to do the demonstrations or practice it, so that learners understand what is being taught, unlike when you teach them things that they cannot see, touch or feel them. T3 indicated that such exposure brings reality into learning science, because they are likely to remember easily what they learnt in the class. This is in line with the study by Akbar (2012) who strongly believes that practical activities rely on the domains of use of real objects and observations, to make teaching and learning real.

These teachers indicated that hands-on practical activities foster interest in learning when learners are touching things. The findings of this study challenge the notion by Millar (2004) who argues that practical activities seem not to help learners to learn in the way that teachers wished them to learn. Similarly, the findings also further challenge Hodson's (1990) view that practical activities are ill-conceived and unproductive. Unlike those studies, participants in this study viewed practical activities as an important tool to unlock what is learnt in theory.

However, some of the teachers acknowledged that use of practical activities has its challenges too and T1 commented that:

> *I do that, it helps. You learn best when you are exposed to materials by feeling or touching, but the fear is that some materials are too fragile, or possibly there are some safety measures that need to be put into consideration. So, exposing learners to these materials may not be… may not be very convenient with all the learners, but it really helps for them to apply hands-on approach. However, sometimes the materials are also not available, thus they are not applied.*

This is similar to what Asheela (2017) reported in her study, that some teachers do not carry out practical activities because there are no resources for practical activities. Further, other participants indicated a similar challenge, that they also sometimes do not do practical activities with the learners, because of the unavailability of resources.

In addition to that, T1 also indicated that as teachers, they also have challenges when it comes to the handling of the apparatus during teaching and learning sessions. The participants further indicated

that as teachers they also needed to be empowered and oriented well enough to enable them to guide learners effectively. This is in line with the findings of the study by Shabani (2016) that strongly emphasises that teachers should be well prepared through professional development activities or interventions to boost their pedagogical approaches for effective teaching and learning. As a result, the well guided and oriented teacher would likely be able to effectively guide learners during practical activities and tend to have more positive attitudes toward teaching and learning of science (Atallah et al., 2010).

4.2.3 Teachers' understanding of the concept of osmosis

One of the challenges facing teachers in helping learners understand the concept of osmosis could be attributed to their own understanding. It emerged from this study that some teachers understand that the process of osmosis involves the movement of water in the cells. For instance, T3 explained osmosis "*as passage of substances in and out of the cell, during osmosis, water moves, but not any other substance involved"*. However, the suggested hands-on activities by the teachers indicated some errors or misconceptions about osmosis. For example, some of the examples shared during the semi-structured interviews detected some errors about the concept *osmosis* and are highlighted in Table 4.2 below.

Table 4.2: Extract from semi-structured interviews: Misconceptions on osmosis

- So this means, is a process of water movement from higher concentration to low (T3).
- Water is moving from the soil where there is high concentration to the roots (T4).
- We used water with different concentrations (T3).
- I can conclude that water moves from higher concentration to low concentration, it is like [basting] from the container (where you are). Like … it is just like when you are in the kitchen washing dishes after that differ from person to person (T3).
- Ions actual dissolve in water … ions dissolve in water, and when water moves from the region of high concentration, [which is the ground], that is osmosis (T1).
- When you are cooking cabbage … or when cooking vegetables … especially carrots, you need to wash them and peel them, and then put them in water. You discover that in the container where you put pieces of carrots you see the colour of the carrots in water; showing that osmosis have taken place (T2).
- You can even ask one of the learners, learners have sprays in their bags and ask who is having a spray or perfume here. Then ask, can you please … spray, and close the door and windows. Then ask the learners, who is in another corner, what observation are you making in the class? From there, can tell, no, I can smell the perfume she applies. Now, the question is that, how that perfume reach you on the other side if you are that far? And then you relate. But that one is more of diffusion; I just have to pay particular attention on the definition that I give to the learners (T1).

With reference to this excerpt, as already discussed in previous sections, the examiners' reports confirmed that the description that referred osmosis *as the movement of water molecules from high concentration to low concentration down the concentration gradient* is incorrect and teachers should refrain from teaching that way. As seen later in Chapter Five, the teachers not understanding or having insufficient knowledge of osmosis when teaching, affects their conceptions and dispositions towards the teaching of this area and the hands-on activities using easily accessible resources that should be associated with it (Ferreira & Morais, 2010).

4.2.4 Teachers' conceptions and dispositions towards teaching osmosis using easily accessible resources

The findings of this study revealed some of the teachers demonstrated positive attitudes towards teaching of osmosis using easily accessible resources. For example, teacher 1 and 2 commented that:

> *It applies no pressure to me. Because even the school is under resourced, it is easy to demonstrate it, because, we… looked at it as an everyday process.* (T1)

> *It is easy to teach this topic; ... learners love this topic of osmosis. It is fun to them, because they end up doing what they learnt during the lesson. It is kind of motivating them to learn more about the topic of osmosis.* (T2)

However, some of the teachers (T4 and T3) revealed a significant challenge that, although osmosis is a nice concept to teach, it may possess some challenges when teaching it, especially in under-resourced schools. For instance, T3 and T4 commented that:

> *It is such a nice feeling … when you are including or incorporating hands on activities; … and I think, it is a challenge because sometimes the most appropriate … tools are not available or things that you are going to use or, so to say, are not available and sometimes it will be difficult for the learners to understand them.* (T3)

> *My feeling is that … osmosis is not something that difficult to understand, but in a school where there are no resources it is a challenge.* (T4)

With reference to the above excerpts, T3 and 4 acknowledged the complexity of learning osmosis. This is in line with what is reported in the Examiner's reports (2017) that learners struggle to answer questions related to osmosis (see Section 1.2.2, Table 4). Hence, the view of T1 indicates that to have a broader understanding of science concepts, the use of easily accessible resources when using hands-on practical activities, would be of significance.

In addition, it was evident that teachers felt that osmosis was one of the important concepts that opened up other learning areas and was perceived important in a worldview context. For instance, T1 reflected that:

> *Definitely, it has a role to play. It ... if you look at it, people … let me say, learners they are studying it for future careers. Some of them are likely to be farmers, and when they become farmers, they should be able to provide reasons.* (T1)

In addition to the importance of osmosis raised in the excerpt, teachers also highlighted some other important concepts that are linked to *osmosis* as emerged in the data from semi-structured interviews. These included: *osmoregulation, dehydration, absorption, diffusion, wilting, respiration, dissolving, and photosynthesis*.

Next, I discuss teachers' experiences when teaching using hands-on practical activities.

4.2.5 Teachers' experiences when teaching using hands-on practical activities

The findings of this study revealed that these teachers seemed to have different experiences in teaching Biology using hands-on practical activities. It is also worth acknowledging that teachers also had some ideas on how best to teach osmosis using hands-on activities. However, the examples they provided showed that they were not adequately exposed to the use of hands-on practical activities using easily accessible resources. This suggested that teachers varied in their experiences on how to assist their learners to have a broader understanding of concepts. For example, T3 stated that: "*You just have to find a way on how to do practicals on that, instead of leaving the topic unpractised. You just have to check into your environment and try if you can get some resources*".

From this excerpt, it is evident that T3 seems to be aware about the possibility of improvisation when resources are scarce. These teachers further indicated that the use of local-based examples help them to teach and ensure that learners understand the concepts. The use of local examples to mediate learning has been recognised in various studies such as Kambeyo (2012), Kambeyo and Ngcoza (2017), Maselwa and Ngcoza (2003) and Shifafure (2014).

4.2.6 Teachers' experiences on teaching osmosis using easily accessible resources

This study revealed that teachers had different experiences on how to teach osmosis. As discussed in the previous section, teachers shared their experiences specifically on teaching osmosis as highlighted in the following excerpts:

> *We can use different materials that can be used to demonstrate … the process of osmosis.* (T2)

> *You can even give … that … can even practice it at home: you have potato and put it in different solutions (hypotonic and hypertonic) and observe after the day, and see what will happen. Meaning, learners can also practice at home.* (T3)

> *I would rather say, in terms of plants how they absorb water; they absorb water. Because, in the soil, there is higher water potential that in the roots.* (T4)

From these excerpts, it is evident that these teachers' experiences varied on how they taught osmosis using easily accessible resources. For example, they mentioned that osmosis can be done using local examples. This finding is in line with the aims of the National Curriculum for Basic Education as discussed in Section 1 and 2 which emphasises the use of the immediate environment and use of everyday materials to teach scientific concepts.

With regards to prior knowledge, although teachers in this study had different experiences and conceptual understandings regarding the mediation of osmosis, it emerged that to explain the osmosis concept clearly to the learners, one should find a way to determine learners' prior knowledge. For example, T1 highlighted that:

> *Well, the process of osmosis it is actually long, I looked at it as a lengthened learning process as they [leaners] learn it from junior grades. So, to broaden it I use the local available examples.* (T1)

Based on the teachers' voices, learners' prior knowledge always needs to be considered during teaching and learning. Some of the teachers in this study believed that it was important to use home-based examples when teaching osmosis. T3, for instance, indicated that using local examples such as potatoes being immersed into different solutions (hypotonic and hypertonic) can be used at home. In Vygotsky' theory (1978), it is emphasised that knowledge is constructed within the learning environments (McRobbie & Tobin, 1997) which in this case are the homes or local environment of the learners. This was also confirmed by the study by Kuhlane (2011) that revealed that the use of prior knowledge and experiences during teaching and learning facilitate meaningful learning. Moreover, Rodrigo et al. (2013) further indicated that insufficient use of prior knowledge during teaching and learning would not benefit learners.

4.3 CONCLUDING REMARKS

In this chapter, I presented, analysed and discussed the data findings gathered from semi-structured interviews of four Grade 11 Biology teachers. The findings of this study revealed that teachers had different understandings on the use of hands-on practical activities. The teachers in this study demonstrated positive dispositions towards the use of hands-on practical activities during teaching; but differed on how they administered them. In addition, teachers also demonstrated positive attitudes towards teaching of osmosis using easily accessible resources. However, challenges regarding inadequate resources in schools were registered as constraining the mediation of learning. This study drew the conclusion that teachers lacked adequate exposure to hands-on activities about osmosis. Therefore, they needed exposure regarding the use of easily accessible resources to regain the precise meaning of osmosis. In the next chapter, I discuss, analyse and discuss the findings of the workshop discussions.

CHAPTER FIVE: DATA ANALYSIS, PRESENTATION AND DISCUSSION (PHASES 2 & 3)

5.1 INTRODUCTION

The goal of my study was to explore how Grade 11 Biology teachers mediate learning of osmosis when using easily accessible resources. In the previous chapter, I presented data generated from semi-structured interviews. In this chapter, I thus present, analyse and discuss the data generated from the workshop discussions (intervention). The main goal of these workshops was to expose teachers to the use of easily accessible resources when mediating the learning of osmosis and they were targeted to answer the following research question:

- What are the enablers or constraints that Grade 11 Biology teachers encounter when developing model lessons on osmosis?

Firstly, I present, analyse and discuss the data generated from the workshops and reflections thereof. Finally, I summarise the findings of each phase.

5.2 DATA PRESENTATION AND DISCUSSION FROM WORKSHOPS (PHASE 2)

The qualitative data I present in this section were gathered through workshop discussions with three Grade 11 Biology teachers who volunteered to be part of the workshops (see Appendix 16).

5.2.1 Brief overview of the intervention in the form of workshops

The main aim of the orientation workshop was to orientate the three grade 11 Biology teachers about the purpose of my study. The workshop took place in Champion Secondary School (pseudonym) and took place in the afternoon so that we did not interfere with the school's programme. It is worth mentioning that although our workshop was planned to take place for about one hour, it lasted for about one and a half hours due to prolonged discussions and social interactions as espoused by Vygotsky (1978). The workshop was attended by three teachers who volunteered to continue participating in the study after the semi-structured interviews that I conducted with four teachers as discussed in Appendix 14. To conceal these teachers' identities, they were coded as T1 - T3.

After greeting and welcoming the participants, I also thanked them for their willingness to take part in my study. Since it was the first workshop, participants introduced themselves by their names and schools where they taught. After the introductions, we started our workshop whereby we discussed the ethical issues underlying this research project (see Section 3.7). These included the right to voluntary participation, positionality, confidentiality and autonomy and teachers' and learners' informed consent letters. Thereafter, participants shared their expectations and these are shown in Table 5.1.

Table 5.1: Participants' workshop expectations

• To get ways how easier to teach osmosis, because it is easy by looking at it but explaining it well to the learners sometimes it is not easy at all (T1, T2); • To know much about osmosis topic and learn more practicals (T3); • To help learners how to answer the questions about practical investigations (T2); • To get a better understanding about the topic (T1, 2, 3); • To get information how best we teach the subject (T1, 2, 3); and • To know which textbooks are good to use when teaching Biology (T2, T1).

In my view, the expectation from the participants indicated that teachers need assistance in various areas. In a broader view, I got an overview of their professional needs of what areas they were eager to be assisted with regarding the mediation of learning of osmosis using easily accessible resources in particular. Such analysis is in line with the study by van Driel et al. (2000) who argue that professional developments that fail to put existing teachers' needs, beliefs and attitudes at the centre are likely to fail. Certainly, I did not want this to happen in my study. Thereafter, I made a PowerPoint presentation regarding the aims and objectives of the study as well as the general overview of the study. After sharing the presentation, participants also shared their feelings about the study and asked for some clarity on some of the aspects.

The followings were some of the comments from the teachers:

> *I personally don't have problem, because I hope this will also benefit us and able to improve our knowledge through practical activities*. (T2)
>
> *Other participants they also agreed to take part in the study and indicated that they fully understand the ethical issues involved in the study*. (T3)

T1 was concerned with the time since these activities were to take place after school hours, and participants were not from the same schools. In order to ensure maximum participation, the participants agreed on the following:

- Activities to be done in the afternoon from 14h00-15h30 (1h30), allowing teachers to break for lunch, and being able to supervise the evening study. Learners also needed a break during lunch and would also need to prepare themselves for the evening study. Some learners are day scholars and also wanted to take part in the lessons, so they needed to be given enough time to travel to their homes.
- The workshops would always take place at the school premises where two teachers are found (school laboratory room); teacher 1 would travel with me to that school; and be taken back after finishing.
- One workshop per week / one day per week, except Fridays and Mondays.

I briefed participants (teachers) about some of the findings that emerged during the semi-structured interviews. This was useful and helped me on how best we could improve the understanding or teaching of osmosis for the learners to have a broader understanding. During the workshop, we addressed some of the misconceptions about osmosis that emerged during the semi-structured interviews. Teachers acknowledged and indicated that the problem was as a result of the textbooks used in schools which have incorrect definitions of osmosis. For example, T3 commented that: "*A definition such as for osmosis has just stuck into our minds since it was previously used, and sometimes one cannot really realise it when teaching*".

Although textbooks have been revised, some schools still use textbooks with some misconceptions (MoE, Examiners' reports, 2011). Hence, teachers are advised to discourage or limit the use of "water concentration" rather use *water potential*. For instance, one of the textbooks indicated that, "*osmosis is a particular case of diffusion, in which water molecules diffuse down their concentration gradient through a partially permeable membrane*" (Jones, 2002, p.33). This is similar to what Arbesman (2012) reported in his study that, the common erroneous ideas about osmosis in science textbooks which state: *osmosis is limited to liquids; osmosis requires attraction forces; and osmosis happens down the concentration gradient*.

In reference to some practical examples during the semi-structured interviews, participants agreed and resolved to make use of the appropriate definitions and practical activities about osmosis. After long deliberations on the use of appropriate terminology, the platform for discussion was again created to reflect and share how best to teach osmosis in general (Table 5.2).

Table 5.2: Extract for workshop discussions

R: How do you find teaching osmosis in general? **T1:** *Personally I found teaching osmosis challenging; reason being that this topic has been incorporated I the curriculum from the junior grades. Learners have been exposed to this concept from grade 8, so they have knowledge about it. The issue is that, at junior grades they might not talk much about this, and may not do any practical on that. It is challenging because there are no materials available for all the topics, some topics you have to hunt the materials and they are expensive if the school has to buy from Medlab*. **T2:** *Myself I didn't find it more challenging but on the part of the learners, they fail sometimes to give the proper terms instead of defining osmosis as movement of water molecules from the region of high water potential to the region of low water potential. So learners define the osmosis as movement of water from high concentration to low concentration, which is the definition of diffusion. Learners lack knowledge of what is moving. So the practical knowledge is the problem, and learners are failing to answer those practical related in paper 3 (during exams). It is bit challenging … and also difficult*. **T3**: *Osmosis in generally it is easy to define; but the problem is the proper understanding to apply it to different contexts. The challenge is that, learners know it theory, but no proper understanding. Even us teachers, when we teach learners, we just make sure that they know the correct definition but not doing practical. Sometimes, we know that you can use this material to do the practical activities but we are not doing it learners or we don't know how we should do it. Its … challenging even sometimes to us teachers. And we also do not have materials in our lab*.

From these excerpts, it could be deduced that although osmosis has been taught from junior grades, it still poses a challenge and teachers have limited knowledge about how to teach this concept in under-resourced schools.

5.2.2 Active participation during the workshop

In this study, participants were engaged in different activities and shared ideas and experiences. This symbolised the active participation and high level of interactions taking place. As discussed earlier, teachers in this study shared their expectations. For instance, T1 and T2 stated that they expected to learn how to teach osmosis using easily accessible resources. This indicated that teachers were eager to learn from one another – learning that was taking place through social interactions (Vygotsky, 1978).

5.3 PRESENTATION OF THE FINDINGS (WORKSHOP 2)

The workshop started with the recap of the previous workshop discussions (workshop orientation). As teachers reflected, they indicated that osmosis was challenging to teach, especially in under resourced schools. Teachers continued to register concerns regarding inadequate resources, and

demonstration of limited exposure to the use of easily accessible resources. This confirmed the findings presented in Section 4 which indicated that teachers showed positive attitudes towards hands-on practical activities, and teaching of osmosis; however, they had concerns with insufficient resources.

5.3.1 Understanding on easily accessible resources

Participants shared their understanding about easily accessible resources and stated that:

> *I think easily accessible resources are the resources that we can get easier without suffering and ordering from the laboratories.* (T1)
>
> *I think those are the materials that we can buy in the local shops or local materials.* (T2)
>
> *In my view those are the resources that available for us to teach the learners, and these resources can be used by teachers and learners.* (T3)

Based on the excerpts, these teachers seemed to have a common understanding on easily accessible resources. For instance, they indicated that these resources were those that were available locally as emphasised by Asheela (2017); Kambeyo and Ngcoza (2017) and Samuel (2017).

5.3.2 Demonstration using easily accessible resources

All participants were engaged in the hands-on practical activities whereby easily accessible resources were used to demonstrate how best to teach osmosis. Teachers used the guideline for the practical activities. The figure below shows the preparation of the potato strips for the practical investigations.

Table 5.3: The preparation of the potato strip and the discussions

T2: So, we need to improvise things ne?
T3: Yes, but now, the one I cut is look too big.
T1: Just a moment … wait you have to measure it. Use a transparent ruler.
T3: the length, width and height ne?
T1: Yaaa!
T3: Ooo ... ndele nee ota kakala nee kashona. (means: Ok, it will be too small then)
T2: For the water, can we take from the tap?

T1: But it has some ions, will affect the results of the experiment. (see Appendix 17)

In activity 2, teachers used eggs to demonstrate what happens if eggs are immersed in the concentrated solution (hypertonic). The following Figure 5.1 shows the eggs as prepared for activity 2. Eggs were immersed in vinegar 24 hours before the activity. The bubbles formed in the acid or vinegar indicates that the process of de-shelling has started and shows the reaction.

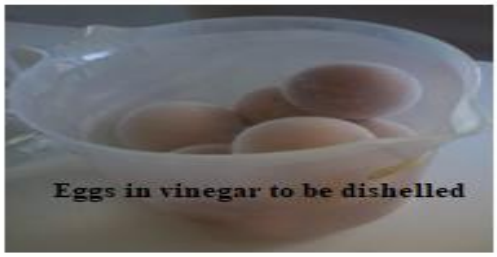


Figure 5.1: Eggs before experiment

The activity was done using the guidelines in Appendix 18.

Figure 5.2 shows the eggs immersed into different solutions during the experiment. For instance: beaker A (water) and Beaker B (highly concentrated salt solution - hypertonic):

Figure 5.2: Eggs immersed in different solutions

After the experiment, participants discussed the results. The following excerpt shows the outcome of the discussions.

Table 5.4: The results of the experiment 2 (on eggs)

Egg in A (water/ hypotonic solution**):** sinks in water, oval-shaped, but look bounced out/stretched out/larger, the interior is suspended and the yolk and albumen look separately; heavy as gained water/ water diffuse in. **Egg in B** (hypertonic solution) floats on top of the solution, but shape remains oval/ but smaller/constrains, softer, interior is not moving; no difference between yolk and albumen (yellowish); lighter as lose water/ water diffuse out.

It can be reasoned from the excerpt that the experiment produced the results as expected. Teachers also reflected that easily accessible resources used in this study worked as well as conventional materials and produced accurate results. This finding challenges the notion by Mensah (2015) who undervalues the use of easily accessible resources in that they lack accuracy and precision.

5.4 DATA PRESENTATION, ANALYSIS AND DISCUSSION FOR THE WORKSHOP 3

The main aim for this workshop was to co-plan and develop model lessons that teachers could use to mediate the learning of osmosis using easily accessible resources. We co-developed two lessons that they then taught in their own classrooms while I observed them. During planning, the materials sought were to be obtained from their local or immediate environments and supplied by the teachers and learners that volunteered. This workshop started with an analysis of the part of the syllabus (on the specific topic) to gain insight into what is expected for the learners to achieve during the lesson (See the Appendix 16).

This workshop aimed at answering the following research question:

> What are the enablers or constraints that Grade 11 Biology teachers encounter when developing model lessons on osmosis?

The following themes were used to present, analyse and discuss the findings of workshop 3. See the themes in Table 5.5.

Table 5.5: The formation of themes and related theory

Episode	**Theme**	**Theory**	
		Literature	**Conceptual/ theoretical framework**
Interactions enable successful lesson co-development Share reflections to improve how to co-plan and co-develop lessons	Social interactions during co-planning and co-development of the lesson	Bashan & Holsblat (2017) Ngcoza (2015)	Vygotsky (1978); Eun (2008); Shabani (2016).
Use of prior and indigenous knowledge in lesson planning help teachers to teach learners in order to make sense of the use of their environments	Prior and indigenous knowledge enrich teaching and learning	Gee (2012); Mukwambo, Ngcoza & Chikunda (2014); Ngcoza (2015); Brookes (2006); Kuhlane (2011).	Vygotsky (1978).
Reflections on the development of model lesson. Oriented well on the use of easily accessible resources, even when teaching in rural area	Reflection on co-planning of the lessons	Asheela (2017); Bergold & Thomas (2012)	Vygotsky (1978).
Use syllabus to plan lessons with all the supporting components Consider what the curriculum requires or curriculum expectations Planning in advance very helpful	Enabling factors that facilitate development of model lessons	MoE, Biology: NSSCO, Syllabus; MoE, NCBE, (2010).	Vygotsky (1978).
Materials not always available or enough; Insufficient exposure on lesson planning; Not easy to improvise Difficult to develop lessons.	Constraints the teachers encounter when developing model lessons	Asheela (2017); Samuel (2017).	Shabani (2016); Eun (2008).

I now discuss each of these themes below.

5.4.1 Social interactions during co-planning and co-development of the lesson

As teachers interacted during the workshop activities, they shared their expertise on how best to develop model lessons. The level of engagement in this workshop was guided by the activities that

were carried out in the workshop. Teachers worked as a team, known as cooperative learning (Vygotsky, 1978) during group activities to develop comprehensive lessons that were then used during the lesson observations. Working as a team is also recognised in the study by Bashan and Holsblat (2017) who view it as a way to support one another to produce a concrete performance and build up strong relationships among the participants. Thus, it was advisable that teachers were taken through such training in order to build up their knowledge and generate good results (Ngcoza & Southwood, 2015). Using the lens of Vygotsky theory (1978), Eun (2008) further stressed that team members learn from one another because they have different levels of understanding and experience.

5.4.2 Prior and indigenous knowledge enrich teaching and learning

Teachers decided that it would be ideal to include prior knowledge in the lesson planning. As collaboratively done, teachers indicated that, the inclusion of prior and indigenous knowledge needed to be part of the introduction. For instance, in this study, teachers felt that the inclusion of prior knowledge and local knowledge would facilitate learning, because it would give an overview of how in-depth they needed to teach.

Table 5.6: An excerpt of teachers' discussions on prior knowledge

T2: Maybe we also need to use local examples […] like [….]
T3: For example, especially okaana to ka kosho takakalamo efimbo ile momeva, like … eshi taka kadja omo okashendja nai (if you bath a baby for long, the body will look changed)
T2: Iyaaaa … odo example twa pumbwa okulongifa odo (those are the examples we need to use, ref. to teaching).
T2: Cont ... anuwa nuundjembele (even the raisins), if you put them in water.
T3: O red meat nayo oiwa nee okulongifa (even its good to use the red meat)
T2: Naame oyo nda dilaadila, the problem it is contagious. So meni lombelela mwinya omuna o higher water potential then the out side surfaces, so omeva otaadimo meni. (I also thought of it (meat), but the problem is that it is contagious. So inside the meat there is higher water potential than outside surfaces, so water will move out).
R: If you want to make it more even exciting you can do it at home and you take a picture of how it looks like after put the salt. Very good example to use, and show the learners pictures.

Based on the excerpt above, the findings revealed that teachers had ideas on how they could include prior knowledge or indigenous practices. Gee (2012) indicates that prior knowledge is one of the important elements that one could use to foster the learners' engagement (Roschelle, 1995). Thus, the inclusion of indigenous practices in science teaching was also supported in the study by Mukwambo et al. (2014) who reasoned that IK enhances learning.

5.4.3 Enabling factors that facilitate development of model lessons

The most common enabler that emerged during the workshop was the use of the syllabus, as it forms the heart of teaching and learning. The results further revealed that learning materials are needed when developing the effective lesson; these include: the syllabus NSSCO Biology; lesson plan format (used the school format); textbooks/any resource books; and materials (resources) for hands-on activities. In addition, it is evident that teachers reflected as follow:

> *Working as a team or group was the most interesting thing that I never had. It gave me the opportunity to see what I should look for when developing a lesson. When we know what we will do especially to involve the learners in getting some of the resources from homes. I know what to do during the experiments, I know the steps.* (T1)

> *Indicated that would have confidence and indicated because lessons were well prepared. I had to break the lesson in parts to make learners understand. I use local materials to present the lesson which are funny to the learners which include learning.* (T2)

> *I was confident in developing the model lessons because learners had the background knowledge or the prior knowledge on osmosis in plants (potatoes). I had no doubt on what I taught because I was well prepared and my lesson was planned.* (T3)

Based on these excerpts, teachers expressed that for appropriate planning, one needs adequate resources (materials), use of prior knowledge and local knowledge for lessons, good lesson planning strategies, and the ability to improvise. The emphasis on what should be considered for the lesson planning was also supported in the study by Aung and Tepsuriwong (2017) who argue that lesson planning is key to teaching and learning, and that pre-activities such as the introduction needs to be well-thought-out to prepare the learners for the actual learning content. Moreover, quality introductions determine the successfulness of the lesson (*ibid*.). Thus, Shabani emphasises the importance of professional development platforms that will empower teachers to improve on their pedagogical approaches and enhance learning.

5.4.4 Constraints encountered by teachers when developing model lessons

Participants indicated that the development of the lessons had its own challenges; however, it differed from teacher to teacher. Namely: insufficient materials, lack of knowledge, inadequate information in textbooks and time constraints. These teachers expressed that:

> *I had a fear that some materials may not be obtained or may not work well. Time was also short to prepare the lessons, and the text books does not have enough information*. (T1)

> *Materials were difficult to find therefore improvising was the option. It was a bit challenging to find out which materials can be used to introduce the topic osmosis to open their minds*. (T2)

> *During the listing of materials need for model lesson discovered that some materials were not available even though I improvise beakers, were not enough so we used bottle containers.* (T3)

From these excerpts, it could be deduced that teachers registered some constraints that interfered with the development of the model lessons. This is in line with some of the challenges that emerged in the study by Asheela (2017) and Samuel (2017). Towards the end of the workshop, teachers also reflected on their exposure to the co-planning and development of the model lessons.

5.4.5 Reflection on co-planning of the lessons

In this study the teachers also reflected that:

> *I know understand, I can plan any lesson well, especially to set up procedures for the activities. It was nice experience.* (T1)

> *This model lesson impacted me in the positive way since, I observe osmosis in reality. I learned that osmosis is a process that took place almost in our daily activities. Example, in dry fruits and preserving food. After experiment I found that out that osmosis even took place when cooking or washing. This had opened up my mind about osmosis, I understand very well to the experiments using local materials.* (T2)

> *After the usage of easily accessible resources I believed that most if not all practicals can be performed at schools like ours with no materials due to fact that I can always improvise by using the local available materials. Meaning, that unavailability of prescribed materials should not be the reason for not doing practicals in schools.* (T3)

In reference to the excerpts above, teachers felt empowered, prepared and ready to implement the lessons on osmosis. This is similar to the study by Asheela (2017) where her findings revealed that teachers' dispositions towards practical activities using easily accessible resources had positively shifted due to the exposure during the intervention.

5.4 CONCLUDING REMARKS

In this chapter I presented, analysed and discussed the data gathered from workshop discussions. Teachers were engaged in various activities during the workshop. As a result, the findings revealed some of the factors that enable and some that constrain teaching and learning of osmosis as registered by the teachers. Some of the enabling factors that were registered included: the availability of the resources (materials), use of prior and local knowledge, lesson planning and preparations and

improvisation of the resources. The constraints during lesson development were insufficient materials, lack of knowledge, inadequate information in textbooks and time constraints.

In the next section, I present, analyse and discuss the findings of the lesson observations of the developed model lessons.

CHAPTER SIX: DATA PRESENTATION, ANALYSIS AND DISCUSSION

6.1. INTRODUCTION

The goal of my study was to explore how Grade 11 Biology teachers mediate learning of osmosis when using easily accessible resources. In the previous section, I presented, analysed and discussed the findings of the data generated from the workshops in which model lessons were co-developed with the teachers. In this chapter, I thus present, analyse and discuss findings from lesson observations of two teachers (Teachers 1 and 2) mediating learning of osmosis using easily accessible resources to do hands-on practical activities. To protect the identity of participants I coded teachers as follow: Teacher 1(T1), Teacher 2 (T2).

As discussed earlier in the previous chapter; teachers co-planned the lessons together and implemented them in their own classrooms while I observed them. During the observations, a critical friend videotaped the lessons so that I could concentrate on doing the observations as well as writing of field notes (see Appendix 12).

6.2 DATA PRESENTATION, ANALYSIS AND DISCUSSION OF THE FINDINGS

The findings of this study revealed that teachers used a variety of mediation techniques or cultural tools (Vygotsky, 1978) to support mediation of learning osmosis. These included: use of prior and indigenous knowledge, use of pedagogical knowledge (PK) as framework to mediate learning, use of easily accessible resources and language (see Table 6.1).

Research question: How do Grade 11 Biology teachers mediate learning of osmosis when using easily accessible resources?

Table 6.1: The formation of episodes, themes and related theory

Episodes	**Theme**	**Theory**	
		Literature	Conceptual/Theoretical Framework
Teacher enlighten and tested learners' prior and indigenous knowledge Use local and indigenous knowledge to influence the learners' understanding on osmosis as scientific concept Use other processes such as food preservation as basic process to understand osmosis	The use of prior and indigenous knowledge to scaffold learning of osmosis	Roschelle, (1995); Kuhlane (2011); Krishnan (2014); Asogwa, et al. (2017); Wessels (2012), Pathan et al., (2018); MoE, Examiner's Reports, 2008.	Vygotsky (1978)
Engaging learners into activities using various methods such as group work stimulate maximum learning; Use of various materials such as easily accessible resources and indigenous practices to osmosis; Do the demonstrations for the learners to guide them for effective learning; Teacher facilitate learning in various ways such as discussions, participation and hands-on activities; Acknowledge learners' contributions, attend to their questions and provide correct definition Challenges encountered during teaching	Teachers Pedagogical Knowledge (PK) as mediation framework to mediate learning of osmosis • Engaging learners in the group discussion and activities stimulate active participation • Facilitate the discussions and hands-on activities • Teacher Pedagogical knowledge (PK) influences mediate of learning • perceived challenges encountered during the lesson presentation	McLeod, (2014); McRobbie & Tobin, (1997); MoE, LCE Policy, (2003); Nyambe (2008), MoE, LCE (2003); Maselwa & Ngcoza (2003); Kambeyo & Ngcoza (2017).	Shulman (1987); Shabani (2008); Vygotsky (1978)
Use of easily accessible resources and indigenous knowledge to teach osmosis Improvisation of the resources	Use of easily accessible resources as tool to mediate learning of osmosis	Asheela (2017); Salam & Olutu (2014); MoE, LCE (2003); Maselwa & Ngcoza (2003) Kambeyo & Ngcoza (2017)	Vygotsky (1978)

I now discuss each of these themes as follow:

6.2.1 The use of prior and indigenous knowledge to scaffold learning of osmosis

The findings revealed that both teachers demonstrated various ways to scaffold learning using learners' prior and indigenous knowledge. However, each teacher approached the learners in their own way depending on the teaching approach of their choice. I observed that both teachers during the introduction to the lesson had elicited prior knowledge (see the field notes Appendix 22).

Table 6.2: The introductory activities for lesson 1

Lesson 1: T1 & T2 Grade: 11 Subject: biology
Topic: Passage of substances

Observation sheet (Introduction) *Adapted from Aung and Tepsuriwong (2017)*

Lesson introductory activities	**T1**	**T2**	**Comments**
Step 1			
Greetings	✓	✓	Happened in both classes
Checking if all present			Done afternoon on voluntarily basis
Informal talk	X	✓	But very rare
Checking homework			
Previewing the lesson	✓	X	T2 wrote on chalkboard
Step 2			
Reinforcing the previous lesson	✓	✓	Both teachers
Eliciting prior knowledge	✓	✓	Both teachers introduced their lessons by reinforcing the previous lesson. T2 spend much time on the introduction

The excerpt above was adapted from Aung and Tepsuriwong (2017) and it puts an emphasis on prior knowledge during the introduction of a lesson whereby the introductory activities also need to be formulated to make sense of what transpired. This is further supported by Roschelle (1995) who argues that to teach science successfully one should consider prior knowledge. The link between the prior knowledge and easily accessible resources is that both relate to what the learners might already know or exposed to in their environments (Roschelle, 1995; Yitbarek, 2012).

Based on the excerpt, both teachers started their lessons by greeting the learners, and then later, started with activities that elicited prior knowledge. In this case, prior knowledge was used to scaffold learning of osmosis. Pathan et al. (2018) argue that scaffolding is a very important element in socio-cultural theory because it helps to support learners to achieve their cognitive potential. Based on Vygotsky's theory, the use of appropriate tools enhances learning (Kozulin et al., 2003; Vygotsky, 1978). This suggests that the use of prior and indigenous knowledge can be used to provide support for learning of osmosis – known as scaffolding.

6.2.1.1 Prior knowledge

I observed that both teachers before they started with their actual mediation process, tried to find out what learners already knew about the topic osmosis.

For example, T2 before starting with her lesson 1, wrote the concept osmosis on the chalkboard, and thereafter asked learners to define it. I observed that T1 assumed that learners already knew the definition of osmosis. However, the multiple answers from the learners were inconsistent and some incorrect; some learners defined *osmosis as movement of molecules from high concentration to low concentration,* which is incorrect. Both teachers introduced their lesson as follows:

> *In the previous lesson we learnt about osmosis in plant cells whereby we used the potato strips which were immersed into different solutions.* (T1)
>
> *We discussed osmosis previously which is 'a movement of water molecules*. (T2)

This indicates that teachers brought in what the learners had already learnt in the previous lesson with the hopes of building on that as a starting point. This finding is similar to Roschelle (1995) who states that prior knowledge provides an anchor for new knowledge.

Table 6.3: An excerpt on prior knowledge

T: All of us here we are in the group mammalian, so meaning our bodies are made up of?
LL: Made up of cells.
T: How does now water move from one cell to another or move from outside the cell into the inside part of the cell?
T: (Cont..) made some drawings on the chalkboard, and at the same time emphasised how to do the biological drawing.
Diagrams of the cells drawn were not clear


Such findings were supported by the National Broad Curriculum for Basic Education that expected each teacher to demonstrate such teaching and learning strategies to elicit learners' prior knowledge and help learners to generate new knowledge (MoE, NCBE, 2010).

Even though both teachers tried to use learners' prior knowledge to introduce their lessons, T2 spent much more time on the activities of prior knowledge so that learners could understand the concept *osmosis*. Emphasising the value of using prior knowledge, Roschelle (1995) and Kuhlane (2011) indicate that if prior knowledge is used constructively it can support and enhance learning. Thus, Aung and Tepsuriwong (2017) strongly feel that the success of the lesson depends on its introduction. This was further strengthened in the study of Wessels (2012), who argues that the background knowledge plays a role in learners' understanding of new concepts. Teachers are, therefore, expected to elicit learners' prior knowledge when mediating learning of osmosis. As much as this study emphasised the use of prior knowledge, teachers also raised a significant concern that sometimes it is not easy to change what is already established in the learner's mind. For instance, learners understood osmosis as the movement of molecules from a region of higher concentration to a region of lower concentration. However, such definitions are no longer accepted, as discussed earlier in Section 1 and 2 and teachers have been advised to refrain from such definitions, as it is not clear which concentrations they are referring to (MoE, Examiner's Reports, 2008). Despite that, learners still use it over and over again, and only remember when the correction is made (see the samples of activity 2, during the classroom observation).

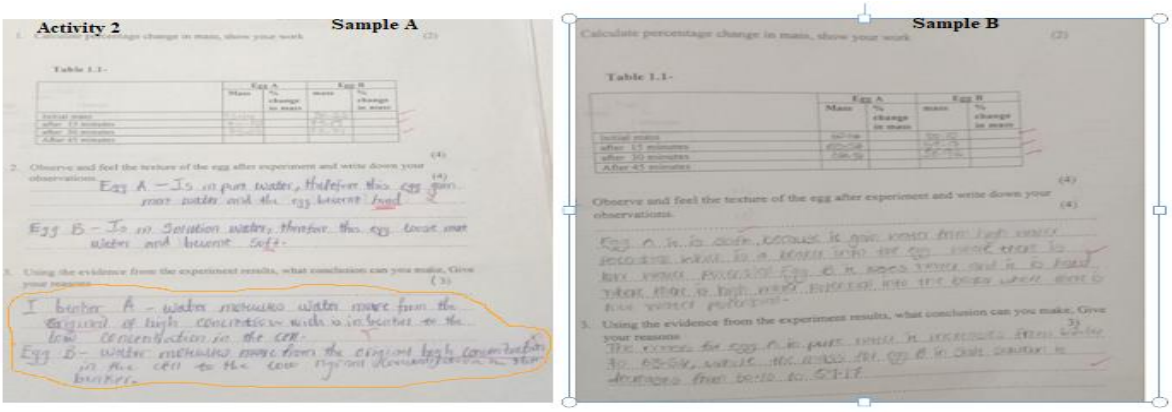


Figure 6.1: Sample of learners' activity 2

For instance, in sample A, learners in that group could not come to a conclusion based on the evidence of the experiment, and they still used the 'concentration'. However, it is also worth mentioning that most of the learners could relate osmosis to the movement of water molecules from a high-water potential.

Next, I discuss how indigenous knowledge can be used as a cultural tool for learning.

6.2.1.2 Indigenous Knowledge (IK)

As part of the introduction, teachers used indigenous practices to scaffold learners' learning of the osmosis concept. For instance, T2 used examples of some *indigenous knowledge* and practices such as food preservation (drying, salting), which happens with the aid of osmosis.

She commented that:

> *Osmosis takes place along with other processes like when we are drying the meat. Most of us here we do not have fridges, where we put our meat, we normally dry it. What we do or what our parents do is to apply a bit of salt on the surface of the meat. This means that if you applied a bit of salt on the surfaces of the meat, there will be differences in water potential inside and outside the meat. Inside the meat there will be more water molecules; while on the surface there will be less water molecules. And us we know the definition of osmosis can now apply. This means, water will move where it is high to where it is low, in this case from the meat to the surface. Once water comes to the surface, then the evaporation will take place. Our concern is now that, what process helps to take water from the cell to the surfaces.* (T2)

Based on the excerpt, T2 explained that osmosis takes place in various important functions such as food preparation. T2 suggested that the exposure of the meat created differences on the water potential gradient and that water has to move down the water potential gradient. This is in line with Krishnan (2014) who indicates that to preserve meat, you need to apply salt to create the differences in the potential gradient so that the meat can dry faster.

Example 2: Used various fruits and vegetables as brought by the learners prior to the lesson. Teachers indicated that our local fruits when they are fresh are eaten; however, there is always a need to preserve (dry) some to eat when they are not naturally available.

Samples of fruits used:

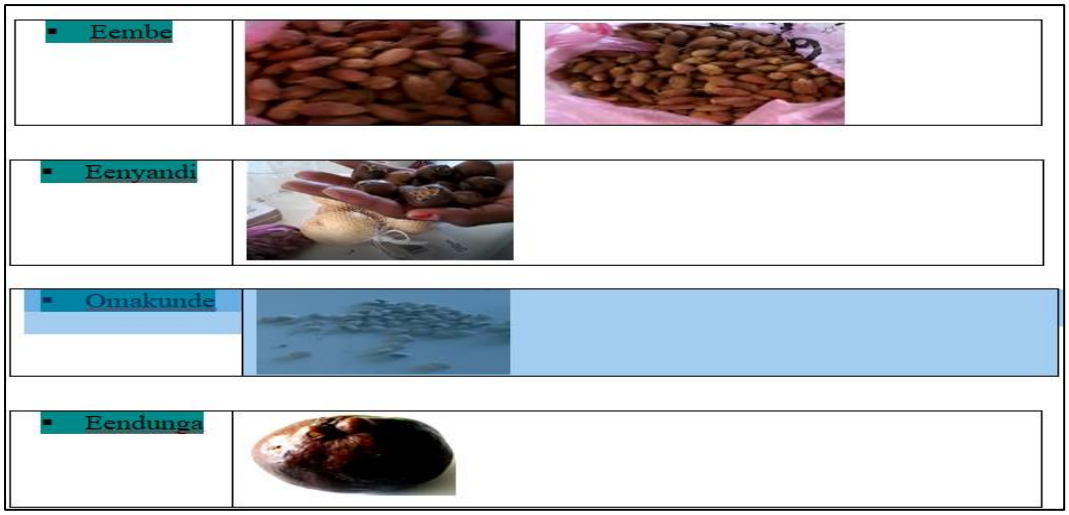


Figure 6.2: Different indigenous fruits brought by the learners

The study by Krishnan (2014) confirms that fruits can be preserved in different ways such as being canned, sugar coated, dried and other methods.

This suggests that learners should master some other concepts related to this exercise such as food preservation (Osungbemiro, Olaniyan, Sanni, & Olajuyigbe, 2013). It also emerged in this study that teachers shared some other examples of osmosis in everyday life situations such as dehydration and long water bathing. The finding of this study opposes the view by Clifton (2017) who feels that the integration of IK compromises scientific discipline and discovery. In my view and from my experience, the integration of IK in the introduction of the lesson suggests that learners are being exposed to resources in their environment which are easy to use and familiar to them. However, there is a knowledge gap when it comes to the use of indigenous resources. Therefore, in line with Mukwambo, Ngcoza and Chikunda (2014) emphasis should be placed on the incorporation of IK into the teaching and learning of science.

Teachers in this study were exposed to the use of easily accessible resources and could integrate prior and indigenous knowledge in their teaching. They felt that it helped their learners to understand the process of osmosis much better.

For instance, T2 reflected that:

> *When introduced my lesson, I used the local fruits like Eenyandi, and I also brought some Omakunde (beans). I brought those materials as part of teaching aids. You know when you have teaching aids and like that one, you bring reality to the class, and when learners learnt the theory and you bring something; they will have a better understanding on that topic.*

Based on the extract, teachers established the value of using indigenous knowledge, and learners realised the importance of their environment. This tallied with the findings of the study of Milne (2017) that says integration of IK helps learners to value their culture and origin. Therefore, it is important that teachers are exposed to the use of easily accessible resources to mediate learning through professional development platforms.

6.2.2 Teachers' pedagogical knowledge as mediation framework to mediate learning of osmosis

The findings of this study revealed that teachers had different pedagogical knowledge when mediating learning of osmosis. Although the teaching approaches differed from teacher to teacher, the findings indicated that both teachers used the learner-centred approach to mediate learning of osmosis. For instance, they both demonstrated the ability to teach learners and expose them to democratic learning where learners' roles were considered (McLeod, 2014). I noted that teachers in this study demonstrated their role as mediators in learning, namely, they engaged learners in activities, assisted learners, used group work, elicited learners' prior and indigenous knowledge, instructed learners, acknowledged learners' contributions and facilitated the discussions during the lessons. The MoE, National Subject Policy (2009) advocates that learners be placed at the centre of learning as active agents that can bring knowledge to school from social experiences such as home and community (McRobbie & Tobin, 1997).

In both lessons it was observed that teachers used group work during the hands-on practical activities. In this case, teachers played a role to ensure that learners worked together and shared responsibilities in their groups. During the stimulated recall interviews, T1 indicated that:

> *I have to give these learners different responsibilities. Some… some learners; I mean we have some learners who have tendency of not doing anything during the lessons or group work. I want them to do the work all. Some measure, some record, some cut the potatoes, observe the outcomes, and any other tasks. You know… some learners who are naturally active will do the work but some will be shy or quite to do the work. This is only the way that all learners can do the work because they know, they are given a responsibility. I know these learners.*

In all the lessons that I observed, learners were working in groups where they were involved in manipulating the hands-on activities (see the picture below).

Figure 6.3: The learners working as a team

I noted that learners were free to participate and share ideas amongst each other (see the extract below):

Table 6.4: An excerpt of group discussion

LL: Ano okwatiwa ngiini? (what is said?) L: (learner answered) okwa tiwaa! Take the potato ndee toshitete ngaha, to landula kutya ota shi tetwa ngahelipi? (it was said that, we should take the potato and cut it as per instructions). LL: Ooo… L: Ndele to shi measure (then you measure it). T: I want you to fill the beaker with 150 ml of distilled water; and you add three spoons of table salt. I didn't say overfill the spoon, just normal and put in your water. In the case the volume of water increases when you add salt; then pour out some after stirring and have the same measurement of 150 ml to get the accurate measurement, your eyes should be at the same level with the level of water.

Figure 6.4: Learners sharing responsibilities during the practical activities

Although, there were social interactions during the group activities, I observed that some groups were too large and that posed challenges to teachers because not all learners were attended to. As a result, some learners could not get an opportunity to fully participate in the activities.

Figure 6.5: A large group during practical activities

To summarise, teachers in this study used group work, discussions, and worksheets during their hands-on practical activities.

6.2.3 Use of easily accessible resources as tools to mediate learning of osmosis

The findings revealed that teachers used easily accessible resources to mediate learning of osmosis as co-planned during the workshop. These teachers and their learners brought the materials which were used during lessons from their homes or from surroundings in their local environments. In this way, learners were exposed to the real-life situations since they were familiar with the materials. This is in line with Atallah et al.'s (2010) findings that real life experiences promote interest and confidence in carrying out hands-on activities. On the use of easily accessible resources, the two teachers reflected that:

> *It was really exciting, as most of the learners were excited, finding the practical lesson more enjoyable, and found out exactly how the process of osmosis occurs. When we were moving around the table, we found out that the eggs that were put into different solutions, they ended up having different mass. The eggs that were put into the hypertonic solution they ended up … losing more water and their mass reduced. And the ones that were put into the hypotonic their initial mass increased. I also found out that learners now got a clear picture on the process of osmosis when they look at the change of mass for the eggs.* (T2)

> *I think it was really a good practical because most of the learners indicated that it was their first time seeing eggs without the shell apart from when they are boiled. Thus they said they want to do it themselves, and keep the eggs for long time in the salt solution to see what will happen.* (T1)

The findings as per the excerpts indicated that teachers felt proud to use easily accessible resources during their lessons and believed that they impacted in their teaching and learning. The excerpt continued to indicate that learners found the lessons enjoyable and seemed learnt something new. This suggested that the learners' interests were stimulated. On the same note Atallah et al. (2010)

also indicated that the use of local or real experiences boosts the interest and confidence of the learners.

In this study, teachers indicated that some of the materials or apparatus was improvised because there were not enough for all the groups. I noted that T1 had a shortage of beakers, for which he improvised. The resources used for the practical investigation were regarded as accessible resources because they are available in the local environment and can be accessed by both the teachers and the learners alike. As discussed in previous sections, accessible resources are the resources that are locally available and improvised resources in the immediate environment (Asheela, 2017; Kambeyo & Ngcoza, 2017; Samuel, 2017).

Table 6.5: Some of the easily accessible resources used

Laboratory material	**Easily accessible resources used**	
Beakers or Measuring cylinders	Feeding bottles	
	Water jag	
	Cool drink bottles (as beakers / containers	
Tiles	Lab benches	
Spatula	Ordinary spoons	
Stirring rod	Ink pen (bottles) / transparent rulers/ rulers	

Table 6.6: The materials brought by the learners and teachers for the lessons

Materials	**Where obtained**
Boiled/ Distilled water	Previously boiled (supplied by the teacher)
Knives/ cutter	Teachers sourced them
Rulers (transparent)	Available in schools (supplied by the teacher)
Table salt	From the kitchen / from learners' houses
Potatoes	From the school garden (teachers supply)
Vinegar	From the local mini-markets/ shops by the teacher)
Spatula	Brought by the teachers
Stirring rod	Any hard plastic/ ruler/ ink pen bottles
feeding bottles	Ask learners to bring pre-used containers from their homes
using cut bottles / beakers	Collect empty cool-drink bottles from the nearby cucashops/ homes/ filling stations
Permanent marker pen	Supplied by the teacher
Eggs	From hens at homes (learners sourced them/ teachers in case)
Weighing scale	Borrowed from nearby school

It seems that the easily accessible resources were successfully used in the study by Asheela (2017) and Kambeyo and Ngcoza (2017) and their findings revealed that the use of resources enhances learning of science. On the use of easily accessible resources, teachers during the stimulated interviews indicated that:

> *Yes, they are getting the desirable results, when I was moving around. Because in the theory we explained that, when the plant put into concentrated solution; water moves out from the cell to the outside, even in the beaker or wherever there is a solution. And, when in the isotonic solution (that is in pure water) water moves in the cell. When I moved around the class in all groups; I found out that learners are getting the desirable results or expected results. Things that we studied in theory now they understand that, that's really what happened.* (T2)

> *Not really, they give the same results as the unimprovised beakers. The challenge was some learners, was like … as like they want the real beakers or apparatus as they supposed to. Then later, they were happy with their results too.* (T1)

Yes, I found it useful. Teaching aids of such kind bring reality. So using those easily accessible resources; let me say they are cheap; you might not need to buy them all. You can find them anytime and everywhere; but using them open up learners' minds because it something that they are used to. (T2)

The bottles I cut them, just to use them as there were no enough beakers. But the good thing was that, the volume for those cut bottles was added there using the feeding bottles (measuring cylinders). (T1)

In their reflections, these teachers indicated that the resources they used were easy to find and cheap; and also, that they worked well and did not affect the intended results. Additionally, 1 indicated that what matters is the correct use of measurements, but the size or type of beakers would not affect the results. The findings challenged the notion by Mensah (2015) and Sabejeje et al. (2017) who thought that some easily accessible resources lack precision and accuracy. Yet, the use of easily accessible resources were used by Asheela (2017), Kambeyo and Ngcoza (2017) and Samuel (2017) in their studies and they all produced desirable results in their own contexts.

These findings lend support to the study by Salami and Olutu (2014) who stress that in case conventional materials are not available, the use of easily accessible resources need to be the immediate intervention. However, this study acknowledged the fact that some teachers excluded hands-on activities in their teaching due to insufficient knowledge and exposure to improvisation or making use of the resources at their disposal (see Asheela, 2017). In this case, this study advocates for professional development platform interventions in the form of workshops to expose Biology teachers to the use of easily accessible resources when mediating the learning of osmosis.

6.3 CONCLUDING REMARKS

In this chapter I presented, analysed and discussed the data gathered from the lesson observations of two Biology teachers, teaching model lessons. The findings revealed that although teachers used a variety of mediation techniques or tools to support mediation of learning osmosis, it also emerged that the use of prior and indigenous knowledge enhanced learning and learners' interests. This suggests that teachers should be exposed through the professional development platforms to establish their pedagogical knowledge on the effective use of prior and indigenous knowledge. Teachers used easily accessible resources which they and their learners brought from their schools, homes, immediate environments, or local shops. During the stimulated recall interview, they made reference to easily accessible and improvised materials as being cheap and readily available that could work the same way as conventional resources. All in all, upon reflection, the teachers who participated in

this study agreed that their participation assisted them on how best they could make use of available indigenous resources to mediate learning of osmosis.

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

CHAPTER SEVEN: SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSION

7.1 INTRODUCTION

The goal of my study was to explore how Grade 11 Biology teachers mediate learning of osmosis when using easily accessible resources. In order to achieve this goal, I employed a qualitative approach to generate data using various methods, namely, semi-structured interviews, workshop discussions, classroom observations and stimulated recall interviews. I used Vygotsky's socio-cultural theory as a theoretical lens to analyse my data in order to answer the following research questions:

To achieve the goal of this study, the following research questions were addressed:

1. What are the Grade 11 Biology teachers' experiences, conceptions and dispositions towards the use of easily accessible resources when mediating learning of osmosis?
2. What are the enablers or constraints that Grade 11 Biology teachers encounter when developing model lessons on osmosis?
3. How do Grade 11 Biology teachers mediate learning of osmosis when using easily accessible resources?

In the previous chapters, I presented, analysed and discussed data generated from semi-structured interviews, workshop discussions, lesson observations and stimulated recall interviews. In this chapter, I present a summary of my findings, recommendations and the conclusion.

7.2 SUMMARY OF FINDINGS

I present the summary of my findings in relation to my four research questions in order to highlight to what extent these were answered.

Research question 1

What are the Grade 11 Biology teachers' experiences, conceptions and disposition towards the use of easily accessible resources when mediating learning of osmosis?

The findings of this study revealed that teachers had different understandings on the use of hands-on practical activities to mediate learning in their Biology classrooms. It emerged, however, that they understood that practical activities involved hands-on activities that required learners to learn by doing or touching. The teachers in this study further demonstrated positive dispositions towards the use of hands-on practical activities during teaching.

Teachers in this study demonstrated positive attitudes towards teaching of osmosis using easily accessible resources. However, challenges regarding inadequate materials were registered as constraining the mediation of learning especially in under resourced schools. Teachers demonstrated experience with regards to the teaching Biology and the osmosis concept in particular. However, most of the suggested practical activities shared during the semi-structured interviews indicated that they required more exposure with regards to the use of easily accessible resources to regain the precise meaning of osmosis. They also acknowledged that prior knowledge and easily accessible resources were important in the teaching and learning of osmosis. Thus, they made referral to the use of local resources for demonstrations, which are easy to use and locally available. However, some teachers expressed a concern that teaching osmosis might be difficult especially in the under-resourced schools due to insufficient exposure (inadequate knowledge) to hands-on activities. This tallied with what was reported in Asheela (2017) that teachers found it difficult to do hands-on practical activities because resources were inadequate. This study drew the conclusion that, although teachers had positive dispositions towards hands-on activities and the teaching of osmosis, it was noted that teachers lacked adequate exposure to hands-on activities about osmosis.

Research question 2

What are the enablers and/or constraints that Grade 11 Biology teachers encounter when developing model lessons on osmosis?

The findings of this study revealed that teachers were involved in various activities during the workshops. This led me to believe that the engagement of participants in various activities during orientation workshops enhanced and symbolised active participation and social interaction among the participants.

As a result, the findings revealed some of the factors that enable and some that constrain teaching and learning of osmosis. The enabling factors included: the availability of the resources (materials), use of prior and indigenous knowledge, lesson planning and preparations and improvisation of the

resources. On the other hand, the constraints to develop lessons included: insufficient materials, lack of knowledge inadequate information in textbooks and time constraints.

Research questions 3

How do Grade 11 Biology teachers mediate learning of osmosis when using easily accessible resources?

The findings of this study revealed that teachers used a variety of mediation techniques or tools to support mediation of learning osmosis. These included use of prior and indigenous knowledge, use of pedagogical knowledge (PK) as a framework to mediate learning and use of easily accessible resources.

It also emerged that the use of prior and indigenous knowledge enhanced learning and learners' interests. Teachers used easily accessible resources which they and their learners brought from their schools, homes, immediate environments, or local shops. During the stimulated recall interviews, teachers made reference to easily accessible resources that worked and gave accurate results as much as the conventional resources.

All in all, the teachers who participated in this study reflected that their participation in this study assisted them on how best they could make use of the resources available to mediate learning of osmosis.

7.3 RECOMMENDATIONS

- There is a need for the teachers to share teaching practices by observing each other's lessons to improve their pedagogical content knowledge (Shulman, 1978);
- Teachers should be exposed through professional development platforms to establish their pedagogical knowledge on the effective use of easily accessible resources, the use prior and indigenous knowledge to mediate learning;
- Teachers should be exposed to different mediation tools to successfully mediate learning;
- Studies on easily accessible resources need to be compiled and shared among the science teachers so that they can make use of those resources when mediating learning;
- More hands-on practical activities should be included in the textbooks and teachers' subject manuals; and
- Local or Indigenous knowledge should be documented and part of the syllabus.

7.4 AREAS FOR FURTHER RESEARCH

- **Further research** is needed to increase awareness with regards to the use of easily accessible resources, which are found to be cheap, readily available and easy to use.
- This study discovered some indigenous knowledge attached to the mediation of learning osmosis that in my view, needs to be strengthened through further research. Another area that needs further researching is to investigate the learning impact of working in a community of practice (that also include parents) to mediate learning of osmosis using indigenous knowledge.
- This study also recommends for a similar study to be carried out on learners instead of on teachers.
- **Curriculum issues:** This study explored the recommendation of the National Curriculum for Basic Education (NCBE) that the use of the immediate environment be practiced in teaching science subjects. However, there is inadequate information on how best teachers may use easily available resources to mediate learning, other than using the complex resources in the suggested practical investigations in the syllabus. This study acknowledges that the content of the syllabus is not an easy thing to change, yet issues that demand immediate attention need to be resolved. Therefore, there is a need to empower teachers to take part in research to further explore how best they can enrich themselves to make meaning of the subject content; and how best they can help learners master the content. This is a process, and the research might influence the curriculum developers to develop a self-explanatory syllabus in the future.
- **Co-planning and development of lessons**: As reported in this study, teachers co-planned and co-developed the lessons that they later implemented in their own classrooms. This study therefore recommends for more research to be conducted in this area to further explore the effectiveness and the impact of co-planning and co-development of lessons on subject knowledge attainment and then on learners' performance.

7.5 LIMITATION OF STUDY

This study only sampled a limited number of Grade 11 Biology teachers in the Oshikoto Region. Therefore, the data findings cannot be generalised to represent all teachers in this region. However, the findings of this study have provided some insights on the potential to use easily accessible resources in mediating learning of the topic of osmosis.

The data generation process was conducted after school hours, which also reduced the amount of data that could have emerged with this research project due to time constraints.

If I were to do this study again, I would extend the duration of the data collection process.

7.6 REFLECTIONS

My research journey is one that I will always remember. I joined Rhodes University in 2017 when I enrolled for my master's degree (in Science Education). It was really a challenge for me to adapt to the culture and the philosophy of the university, but with all the guidance and assistance from my supervisor Prof. Ken and my teammates, I coped. I learnt much in the field of practical activities with the use of easily accessible resources and indigenous knowledge.

Essentially, I was exposed to the use of easily accessible resources through various platforms such as a presentation by Eva Asheela. Her study motivated me to explore the use of easily accessible resources when mediating learning of osmosis. This was a learning experience; I started exploring it myself and also discovered that local knowledge or indigenous knowledge related to the teaching of osmosis. That was amazing! Since that was a new discovery, I planned to continue exploring more on that topic. The research design course I attended in 2017 in Grahamstown motivated me to take up the challenge of research, however, I was still undecided on the topic of study. Since then, various presentations during the contact sessions in different learning areas and the assistance from my supervisors and teammates helped me to finally decide on my topic. Before my research journey began, I had to have my proposal approved. Afterwards, the data generation process started in 2018. Since the entire process in this research had its ups and downs, I had to be resilient and work hard all the time.

Another experience which was an eye-opener and a memorable experience was teaming up with Biology teachers for my study. This was great exposure and an experience to closely work together with the participants. I learnt a lot from them and learnt to value others' contributions. I also came to the realisation that team work is a solution to problem solving. In the process during the classroom observations, I picked out some of the best practices that I believe I will share with other Biology teachers in the region.

Additionally, I obtained all the needed skills, knowledge and experience on academic writing. I found the research journey rewarding and fruitful!

7.7 CONCLUSION

This study explored how Grade 11 Biology teachers mediated learning of osmosis when using easily accessible resources. In order to realise this goal, I collected data based on the research questions

using semi-structured interviews, workshop discussions, lesson observations and stimulated recall interviews.

This study began with the semi-structured interviews that explored Grade 11 Biology teachers' experiences, conceptions and dispositions towards the use of easily accessible resources when mediating learning of osmosis. In brief, the findings revealed that teachers demonstrated positive attitudes towards teaching of osmosis using easily accessible resources. However, challenges regarding inadequate materials that hindered teaching and learning processes were registered. The second research question aimed at identifying the enablers or constraints that Grade 11 Biology teachers encountered when developing model lessons on osmosis. In brief, the result revealed that the availability of the resources (materials), use of prior and indigenous knowledge, lesson planning and preparations and improvisation of resources were amongst the factors that enabled development of the model lessons. Furthermore, the findings revealed some constraints such as insufficient materials, lack of knowledge, inadequate information in textbooks and time limitations.

Finally, the study explored the mediation of learning osmosis when using easily accessible resources. In brief, the findings revealed that teachers used a variety of mediation tools to enhance learning. These included: use of prior and indigenous knowledge, use of pedagogical knowledge (PK) as a framework to mediate learning and use of easily accessible resources. Therefore, I would say all my research questions were answered. In the case of any knowledge gaps discovered they were then referred to areas for further researching. Moreover, limitations of the study, recommendations and reflections were discussed in this chapter.

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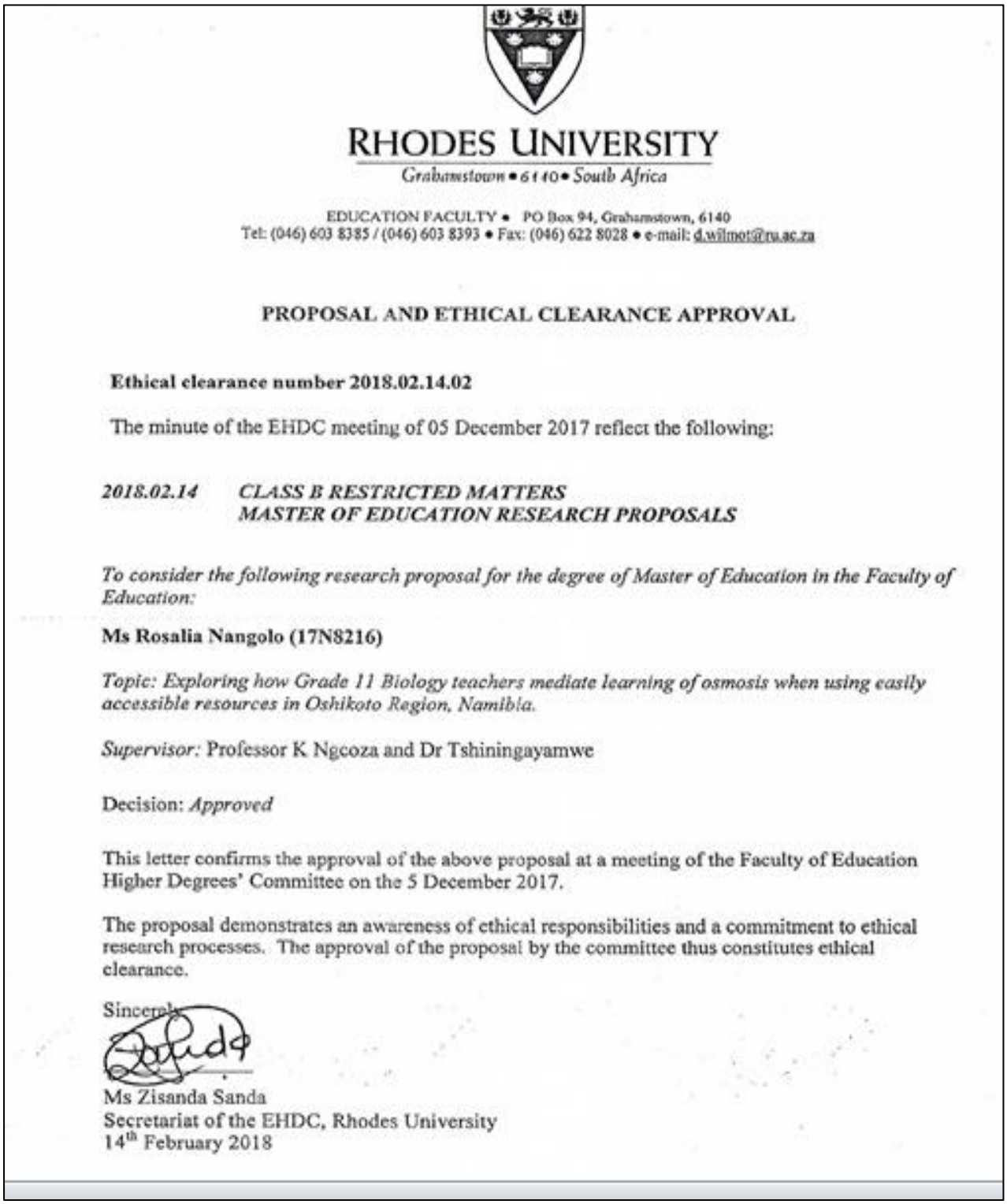
APPENDICES
Appendix 1: Ethical Clearance



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PROPOSAL AND ETHICAL CLEARANCE APPROVAL

Ethical clearance number 2018.02.14.02

The minute of the EHDC meeting of 05 December 2017 reflect the following:

2018.02.14 ***CLASS B RESTRICTED MATTERS***
MASTER OF EDUCATION RESEARCH PROPOSALS

To consider the following research proposal for the degree of Master of Education in the Faculty of Education:

Ms Rosalia Nangolo (17N8216)

Topic: Exploring how Grade 11 Biology teachers mediate learning of osmosis when using easily accessible resources in Oshikoto Region, Namibia.

Supervisor: Professor K Ngcoza and Dr Tshiningayamwe

Decision: *Approved*

This letter confirms the approval of the above proposal at a meeting of the Faculty of Education Higher Degrees' Committee on the 5 December 2017.

The proposal demonstrates an awareness of ethical responsibilities and a commitment to ethical research processes. The approval of the proposal by the committee thus constitutes ethical clearance.

Sincerely

Ms Zisanda Sanda
Secretariat of the EHDC, Rhodes University
14th February 2018

Appendix 2: Letter from the Director of Education

REPUBLIC OF NAMIBIA

OSHIKOTO REGIONAL COUNCIL
DIRECTORATE OF EDUCATION, ARTS AND CULTURE

Tel (065) 281900
Fax (065) 240315
Enq: Ms H Tende

Private Bag 2028
ONDANGWA
22 February 2018

Ref: 12/3/10/1

Mr Rosalia N. Nangolo
P.O BOX 2263
Ondangwa

Dear Mrs Nangolo

RE: PERMISSION TO CONDUCT RESEARCH IN TH SCHOOLS IN OSHIKOTO REGION

Our office acknowledge receipt of your letter dated 15 February 2018, seeking for permission from the Director to conduct a research Oshikoto Region. Kindly be informed that permission is hereby granted to you to carry out your research in selected schools in Oshikoto Region.

It is very important that your research does not interfere with the normal teaching and learning process at schools, any participation either by teachers or learners should be on a voluntary basis and the information to be gathered should be used for research purposes only. Please consult the school principals well in advance to make further arrangements.

Be further informed that some of the schools are private schools and the onus lies with the Board of Directors to grand you permission, in principle, we do not have an objection to your research study.

Thank you for showing interest to do research in Oshikoto Region. It is our sincere hope that the information you are going to get will be useful towards the completion of your qualification.

Yours faithfully

Director
22 FEB 2018

MR LAMEK T. KAFIDI
DIRECTOR OF EDUCATION
OSHIKOTO REGION

OSHIKOTO REGIONAL COUNCIL
PRIVATE BAG 2028
ONDANGWA

Appendix 3: Letter from the Inspector of Education

REPUBLIC OF NAMIBIA
OSHIKOTO REGIONAL COUNCIL
DIRECTORATE OF EDUCATION
ONYUULAYE CIRCUIT

Tel: 065-289600
Fax: 065-289003
Enquiries: Abraham Nafine
E-Mail address: abrahamnafine@gmail.com

Private Bag 2028
Ondangwa
10 April 2018

Addressed to:

Ms Rosalia N.Nangolo
P.O. Box 2263
Ondangwa

RE: Request for permission to conduct research at schools in Oshikoto Region on the topic: Exploring how Grade 11 Biology teachers mediate learning of osmosis when using easily accessible resources in Oshikoto Region.

Dear Ms. Nangolo

The above matter refers: Your letter dated 22 February 2018 is hereby acknowledged received and permission granted for you to undertake the research/study in schools in our circuit, provided that the teaching and learning at school will not be disrupted.

I wish you all the best in your studies.

Yours in Education

ABRAHAM NAFINE
INSPECTOR OF EDUCATION
ONYUULAYE CIRCUIT

MINISTRY OF EDUCATION, ARTS & CULTURE
INSPECTOR OF EDUCATION
2018 -04- 10
ONDANGWA
ONYUULAYE CIRCUIT
REPUBLIC OF NAMIBIA

Appendix 4: Teacher's Consent

APPENDIX D: CONSENT FORM FOR TEACHERS

P.O. BOX: 2263
ONDANGWA

INFORMED CONSENT FORM FOR TEACHERS

Research Project Title:	Exploring how Grade 11 Biology teachers mediate learning of osmosis when using easily accessible resources in the Oshikoto Region.
Principal Investigator(s):	Rosalia Ndawapeka Nangolo, MED Student – Rhodes University

Participation Information
• I understand the purpose of the research study and my involvement in it; • I understand the risks and benefits of participating in this research study; • I understand that I may withdraw from the research study at any stage without any penalty; • I understand that participation in this research study is done on a voluntary basis; • I understand that while information gained during the study may be published, I will remain anonymous and no reference will be made to me by name or student number; • I understand that other data collection requirements particular to this research, e.g. (test results, personal information, video recording) may be used; • I understand and agree that the interviews will be recorded electronically; • I understand that I will be given the opportunity to read and comment on the transcribed interview notes; • I confirm that I am not participating in this study for financial gain.

Information Explanation
The above information was explained to me by: Rosalia Ndawapeka Nangolo (Researcher)

The above information was explained to me in English and I am in command of this language:

Voluntary Consent	
I, [redacted] hereby voluntarily consent to participate in the above-mentioned research	
Signature:	Date: / / 08-03-2018

Investigator Declaration	
I, Rosalia Ndawapeka Nangolo (Researcher), declare that I have explained all the participant's information to the participant and have truthfully answered all questions asked me by the participant.	
Signature:	Date: 08/03/2018

Appendix 5: Signed consent from learners and parent

March 8, 2018

Dear Parent

Your child is invited to participate in a study entitled: *Exploring how Grade 11 Biology teachers mediate learning of osmosis when using easily accessible resources in the Oshikoto Region.*

My name is Rosalia Ndawapeka Nangolo, a Master's degree student at Rhodes University (RU) in Grahamstown, South Africa.

The research I wish to conduct for my master's full thesis requires me to observe Biology Grade 11 teachers teaching. In this case, your child will be in the class where observations will take place, although my focus will be on teachers. My study also requires video recording the lessons during observations. The aim of this research is to explore how teachers mediate the learning of osmosis using easily accessible resources. Your child's participation is important because a teacher needs learners to enable teaching.

There are no foreseeable risks to your child by participating in the study. Your child will receive no direct benefit from participating in the study other than educational related ones. Your child will not receive any payment for being part of the study. Your child's participation is voluntarily and they can refuse to be part of the class or withdraw anytime without any penalty. As a parent you can withhold consent for them to participate in the study or withdraw your consent at any time without any penalty or reason.

The name of your child will not appear in the report and their identity will be kept confidential. Your signatures indicate that you agree for your child to participate and you understand all the ethics involved.

Name of child: [redacted]

Signature: [redacted]

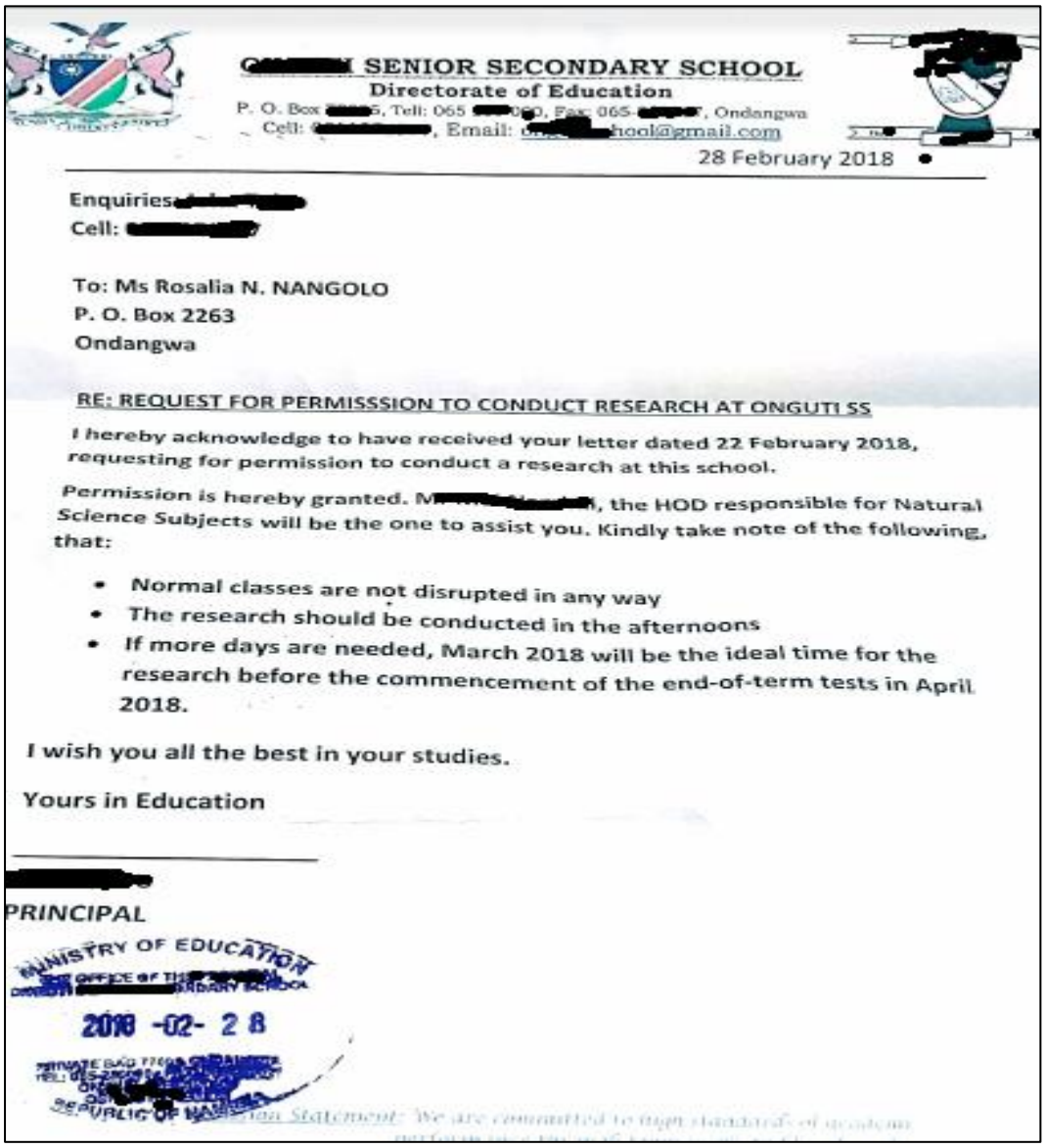
[redacted] [redacted] 14-03-18

Parent/guardian's name | Signature | Date

Rosalia Ndawapeka Nangolo | [signature] | 08/03/2018

Researcher's name | Researcher's signature | Date

Appendix 6: Letter from School Principal



[redacted] SENIOR SECONDARY SCHOOL
Directorate of Education
P. O. Box [redacted], Tell: 065 [redacted], Fax: 065-[redacted], Ondangwa
Cell: [redacted], Email: [redacted]hool@gmail.com

28 February 2018

Enquiries [redacted]
Cell: [redacted]

To: Ms Rosalia N. NANGOLO
P. O. Box 2263
Ondangwa

RE: REQUEST FOR PERMISSSION TO CONDUCT RESEARCH AT ONGUTI SS

I hereby acknowledge to have received your letter dated 22 February 2018, requesting for permission to conduct a research at this school.

Permission is hereby granted. M[redacted], the HOD responsible for Natural Science Subjects will be the one to assist you. Kindly take note of the following, that:

- Normal classes are not disrupted in any way
- The research should be conducted in the afternoons
- If more days are needed, March 2018 will be the ideal time for the research before the commencement of the end-of-term tests in April 2018.

I wish you all the best in your studies.

Yours in Education

[redacted]
PRINCIPAL

MINISTRY OF EDUCATION
[redacted] SECONDARY SCHOOL
2018 -02- 28

Appendix 7: Letter to Director of Education

Director of Education
Directorate of Education: Oshikoto
Private Bag 2028, Ondangwa

P.O. Box 2263
Ondangwa
15th February 2018

Dear Sir

REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN THE SCHOOLS IN YOUR REGION.

My name is Rosalia Ndawapeka Nangolo, a Master's degree student at Rhodes University (RU) in Grahamstown, South Africa. This research will be conducted under the supervision of Prof. Kenneth M. Ngcoza and my co-supervisor Dr Sirkka Tshiningayamwe.

My provisional title is: *Exploring how Grade 11 Biology teachers mediate learning of osmosis when using easily accessible resources in the Oshikoto Region.* The research I wish to conduct for my Master's full thesis requires me to pilot my interview questions before the research starts to test if my questions are appropriate for my study. In this case, I will pilot the semi-structured interviews with two Grade 11 Biology teachers.

With my data collection, I will interview four Biology Grade 11 teachers from different schools in your region. Thereafter, I will only work with two teachers who will attend the workshop on osmosis, observe their lessons and do the stimulated recall interviews.

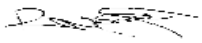
Therefore, this letter serves to seek formal consent to approach Biology Grade 11 teachers (focus participants), the learners and the parents of the learners in their classes where the observation will take place. Further, I would be grateful if I may access appropriate documents at their discretion. For this reason I request your permission to visit schools on the date (that will be known to you in due course) to conduct my research as outlined in my research proposal.

I attach a copy of my research proposal which includes copies of the consent and assent forms to be used in the research process. I have also attached my Clearance Certificate from the Ethical Higher Degree Committee. As part of this I undertake to ensure that the name of the schools and all participants will be replaced with pseudonyms and that all the material I collect as part of the research will be accessible only to myself and my supervisors.

Upon completion of the study, I undertake to provide your office, schools and the teachers who participated with access to the research findings. If you require any further information, please do not hesitate to contact me at +264-811422913 (contact number) and rosaliahamalwa@yahoo.com (my e-mail address).

Thank you for your time and consideration in this matter.

Yours sincerely



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Ms Rosalia Ndawapeka Nangolo Student No. 17N821-6, Rhodes University

Appendix 8: Letter to the teacher

P.O.BOX 2263
ONDANGWA

Participant (Teacher)
Selected school
Oshikoto Region

26 February 2018

Dear Participant (Teacher)
Re: Invitation to participate in a research study (teachers)
You are invited to participate in a research study entitled, *Exploring how Grade 11 Biology teachers mediate learning of osmosis when using easily accessible resources in the Oshikoto Region*. The aim of this research is to explore how teachers mediate the learning of osmosis using easily accessible resources. Your participation is important to share your opinion and experience in the research topic. This research might contribute to construction of knowledge and professional development. After the data collection, information on how to access the research findings will be made available to your institution.

The research will be undertaken through semi-structured interviews, workshops, observation and stimulated recall interviews. Your participation in the research is anonymous and your identity will not be revealed. The collection of this data will require between one and two weeks.

If you agree to participate, we will explain in more detail what would be expected of you, and provide you with the information you need to understand the research. This will be done at the workshop I will organise with you before the commencement of the research. These guidelines would include potential risks, benefits, and your rights as a participant. This study has been approved by the Ethics Committee of the Faculty of Education and the permission is granted by the Director of Education: Oshikoto Region.

Participation in this research is voluntary and a positive response to this letter of invitation does not oblige you to take part in this research. To participate, you will be asked to sign a Consent Form to confirm that you understand and agree to the conditions, prior to the commencement of lesson observations, and stimulated recall interviews. Both lesson observations and stimulated recall interviews will be video recorded. Please note that you have the right to withdraw at any given time during the study without any penalty or negative consequences. Your name will not appear in the report and you will remain anonymous.

Thank you for your time and I hope that you will respond favourably to my request.

Yours sincerely,

Ms Rosalia Ndawapeka Nangolo
MED Student (Rhodes University)

Prof. Kenneth M. Ngcoza (Supervisor)

Dr Sirkka Tshiningayamwe (Co-supervisor)

Appendix 9: Letter to schools for permission

Letter for permission to school:

P.O. BOX: 2263

The principal (Selected schools)

Secondary Schools

26th February 2018

Oshikoto Region

Namibia

Dear Sir

REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN YOUR SCHOOL.

My name is Rosalia Ndawapeka Nangolo, a Master's degree student at Rhodes University (RU) in Grahamstown, South Africa. This research will be conducted under the supervision of Prof. Kenneth M. Ngcoza and my co-supervisor Dr Sirkka Tshiningayamwe.

My provisional title is: *Exploring how Grade 11 Biology teachers mediate learning of osmosis when using easily accessible resources in the Oshikoto Region.* The research I wish to conduct for my Master's full thesis requires me to have semi-structured interviews, workshops, observation (lessons) and then stimulated recall interviews with a Biology Grade 11 teacher in your school.

Therefore, this letter serves to seek formal consent to approach Biology Grade 11 teachers (as my participants), the learners and the parents of the learners in their classes where the observation will take place. Further, I would be grateful if I may access appropriate documents at their discretion.

For this reason, I request your permission to visit your school on the date (that will be known to you in due course) to conduct my research as outlined in my research proposal.

I attached a copy of my Ethical Clearance from Rhodes University and the permission letter from the Director of Education, Oshikoto Region.

As part of this, I undertake to ensure that the name of the schools and all participants will be replaced with pseudonyms and that all the material I collect as part of the research will be accessible only to myself and my supervisors.

Upon completion of the study, I undertake to provide your office and the teacher who participated with access to the research findings. If you require any further information, please do not hesitate to contact me at +264-811422913 (contact number) and rosaliahamalwa@yahoo.com (my e-mail address).

Thank you for your time and consideration in this matter.

Yours sincerely

……

Ms Rosalia Ndawapeka Nangolo

Student No. 17N821-6

Rhodes University

Appendix 10: Extracts from Examiner's reports on osmosis

Extract 1

2008, Paper 3

2. (D) (ii) this question was poorly answered. Most candidates knew that osmosis was somehow involved, but could not explain the changes that had taken place in the cell. A shrunken or smaller vacuole means that water moves out of vacuole and not just out of the cell. ***Candidates are also advised to describe osmosis in terms of water potential, but not in terms of high concentration and low concentration, as it is always clear which concentration they are referring to, e.g. the concentration of salt, the concentration of the water or the concentration of the solution (P. 43)***

2009

*2(b) (ii) answers to this question were generally poorer than expected and less than half of the candidates wrote correctly about water potential. T****eachers are advised to use water potential (p. 52).***

2010, Paper 3

Many candidates referred to the differences in sugar concentration rather than the water potential difference and did not give full explanations of water moving into or out of the epidermal cells/ vacuoles and linking this to the change in length. *Weaker responses omitted reference to osmosis or water at all and gave only a description of their results, i.e. giving the length changes for each concentration but no explanation (71).*

Osmosis

2010, Paper 2

Partial permeability was not well known to the majority of candidates.

A few candidates mentioned a property of the wall; they looked at the tube as a whole p.68.

partially permeable / permeable to small molecules / allow small molecules to pass;

® semi / selectively / differentially permeable p. 67

2011, Paper 2

2. (a) (iii) *Most candidates defined "osmosis" and failed to "explain" how water is absorbed.* ***Centres are advised to discourage or limit the use of "water concentration". Rather use water potential"****, as most candidates used these terms interchangeably and thus could not score the required marks.*

(iv) *This section of the question was poorly answered as candidates failed to use proper* terminology of "**diffuse**" and made reference to "**enter**" p. 62

2011, Paper 3

Learners were struggling to answer the question and give the correct answer related to:

2 (a) (iii) root hairs *absorb water (from the soil) by osmosis down a water potential (Ψ) gradient / from a high water potential in the soil to a low - water potential in the root hair cells / from a high- water concentration in the soil a low -water concentration in the root hair cells across / through a partially / differentially / selective permeable membrane;* ***R semi R***

Definition of osmosis on its own *root hair cells provides a large surface area p. 63.*

2012, paper 2

5 (b) (ii) *Poorly answered. Candidates failed to describe the movement of water from the root and rather referred to the definition of "osmosis*

2013, Paper 2

(ii) They got confused between describe and explain questions and swopped the answers.

Teachers must refrain from teaching "high water concentration" and "low water concentration". Teach the learners about the difference in water potential.

2017

Some learners were confused by some terminologies such as plasmolysis, shrink and turgid. Candidates explained the plant cell instead of the animal cell (F) and many wrote the definition of osmosis without an indication of where the water is coming from and going to (p. 45).

Extract 2

2013 *It is clear that learners are not exposed to practical work (p. 65). Teachers must focus on the practical investigations in the syllabi. It came out very clearly that learners are not familiar with simple experiments (p. 65).General knowledge of science terms is still matter of concern.*

2016 *The majority of candidates did not perform well in this paper 3. Many candidates gained very low scores and only a few performed excellently and were awarded high marks. Some answers were left blank, and this seemed to be through lack of knowledge rather than lack of time.*

Some processes, are very difficult for candidates to explain in their own words, and marks are more accessible if the correct wording is known (p. 58)

2017 *Some candidates answered using theoretical knowledge instead of the information contained in the stem of the question (p. 52). Teachers should do practical work with the learners to understand the content better (p. 44).*

Extract 3

2008, Paper 3 *2. (D) (ii) this question was poorly answered. Most candidates knew that osmosis was somehow involved, but could not explain the changes that had taken place in the cell. A shrunken or smaller vacuole means that water moves out of vacuole and not just out of the cell.* ***Candidates are also advised to describe osmosis in terms of water potential, but not in terms of high concentration and low concentration, as it is always clear which concentration they are referring to, e.g. the concentration of salt, the concentration of the water or the concentration of the solution (P. 43)***

2009 *2(b) (ii) answers to this question were generally poorer than expected and less than half of the candidates wrote correctly about water potential. T****eachers are advised to use water potential (p. 52).***

2010, Paper 3 ***Many candidates referred to the differences in sugar concentration rather than the water potential difference and did not give full explanations of water moving into or out of the***

Osmosis	***epidermal cells/ vacuoles and linking this to the change in length.*** *Weaker responses omitted reference to osmosis or water at all and gave only a description of their results, i.e. giving the length changes for each concentration but no explanation (71).*
2010, Paper 2	*Partial permeability was not well known to the majority of candidates.* *A few candidates mentioned a property of the wall; they looked at the tube as a whole p.68.* *partially permeable / permeable to small molecules / allow small molecules to pass;* ***® semi / selectively / differentially permeable p. 67***
2011, Paper 2	***2. (a) (iii)*** *Most candidates defined "osmosis" and failed to "explain" how water is absorbed.* ***Centres are advised to discourage or limit the use of "water concentration". Rather use water potential"****, as most candidates used these terms interchangeably and thus could not score the required marks.* ***(iv)*** *This section of the question was poorly answered as candidates failed to use proper* terminology of "**diffuse**" and made reference to "**enter**" p. 62
2011, Paper 3	*Learners were struggling to answer the question and give the correct answer related to:* ***2 (a) (iii) root hairs*** *absorb water (from the soil) by osmosis down a water potential (Ψ) gradient / from a high water potential in the soil to a low - water potential in the root hair cells / from a high- water concentration in the soil a low -water concentration in the root hair cells across / through a partially / differentially / selective permeable membrane;* ***R semi R*** ***Definition of osmosis on its own*** *root hair cells provides a large surface area p. 63.*
2012, paper 2	***5 (b) (ii)*** *Poorly answered. Candidates failed to describe the movement of water from the root and rather referred to the definition of "osmosis*
2013, Paper 2	*(ii) They got confused between describe and explain questions and swopped the answers.* ***Teachers must refrain from teaching "high water concentration" and "low water concentration". Teach the learners about the difference in water potential.***
2017	*Some learners were confused by some terminologies such as plasmolysis, shrink and turgid. Candidates explained the plant cell instead of the animal cell (F) and many wrote the definition of osmosis without an indication of where the water is coming from and going to (p. 45).*

Extract 4

Examination	Comments
2008	***It is worrying that ability of candidates to answer Biology questions does not really seem to improve over the years (p. 42).*** ***Hardly, anybody will be able to explain the effect of placing the plant into salt solution if they have not really thought about the problem. Most candidates can learn the basic facts in Biology but needs every good teacher to enable candidates to apply their knowledge (p. 42).***

2011	*Designing an experiment proved difficult for some. Although they had an idea of what was required, it was not followed through on the basis of giving practical instructions, and often the experiment they described did not investigate the correct feature. p. 69.*
2012,	*General knowledge of science terms is still a matter of concern. It was clear that learners are not properly exposed to practical work. Teachers should focus on the spelling of science terms and scientific processes (64).* *Teachers must focus more on the practical suggestions in the syllabi. It came out very clearly that learners are not familiar with simple experiments (p. 64)*
2013	*It is clear that learners are not exposed to practical work (p. 65). Teachers must focus on the practical investigations in the syllabi. It came out very clearly that learners are not familiar with simple experiments (p. 65).General knowledge of science terms is still matter of concern.*
2016	*The majority of candidates did not perform well in this paper 3. Many candidates gained very low scores and only a few performed excellently and were awarded high marks. Some answers were left blank, and this seemed to be through lack of knowledge rather than lack of time.* *Some processes, are very difficult for candidates to explain in their own words, and marks are more accessible if the correct wording is known (p. 58)*
2017	*Some candidates answered using theoretical knowledge instead of the information contained in the stem of the question (p. 52). Teachers should do practical work with the learners to understand the content better (p. 44).*

Appendix 11: Forming categories, sub-theme and themes

Sub-categories	Categories	Sub- themes	Theme
	Are activities that apply hand-on or minds-on Physical activities which uses process skills to master the content, bring reality Activities that require experiments and require learners to learn by doing Practical activities improves performance Putting what learnt into practice to improve the understanding in the subject	Hands-on activities requires a use of process skills to master the content, bring reality and improve performance Putting what learnt in the class into practice	**Hands-on practical activities help to foster learning and process skills**
	Putting what is learnt into practice To practice what they learn in the class Using practical activities improve understanding	Putting the theory in to practice	
	Conception and disposition towards practical activities: You learn best when exposed to materials Materials may not convenient to all learners, but really help them to learn Feeling that learners should do more practical activities to learn best It is nice feeling and learning best when incorporating hand-on Teaching learners practically motivate the learners to learn more about osmosis Conception and disposition towards teaching osmosis	Conception and disposition towards practical activities: Learn best when exposed to hands-on activities feeling positive about hands-on activities as learner' learn best and improve Hands-on motivates learners to learn	**Teachers conception and dispositions on incorporation of hands-on activities into teaching**

	Feelings quite good; Like the topic osmosis, it is fun to the learners Easy to teach and demonstrate even in under-resourced schools (T1) Challenging to teach when no appropriate materials available (T3) Osmosis is not difficult to understand, when no resources (T4) My feeling quite good to teach osmosis comparing to other topics Provide future plans and broader understanding (worldview)	Conception and disposition towards teaching osmosis Feeling good teaching osmosis because it's fun and easy even in under-resourced schools (T1,T3) Osmosis is challenging to teach in schools where no resources are available; Osmosis concept give broader understanding on career related information (such as farmers)	**Teachers conception and disposition towards teaching osmosis using easily accessible resources**
	Teachers' experience on hands-on activities Home and school-based experiments Give examples when teaching Finding a way how to teach a topic Teaching theory and summarize possible results or outcome Explain terminologies Use of prior knowledge Teachers experience in teaching osmosis Sowing the learners how water moves from using a potato Observe the plant immersed in hypotonic and hypertonic solution Explain to the learners what osmosis all about Use different materials used to demonstrate osmosis I try to design a simple experiment theoretically (if were allowed to use		

	example of liver cell (fresh one). We design the practical with the aim of the activity, materials, procedures Explain on how dehydration occurs		
	Using local available resources; things that happen in the environment Using local examples: o when cooking o when bathing or washing	Use of easily available resources when mediating learning of osmosis	
	Handing of materials is a challenge Inadequate materials to carry hands-on activities Misconceptions on the topic osmosis		

Table showing how sub-themes and themes were formed

Sub-categories	Sub- themes	Theme
	Hands-on activities requires a use of process skills to master the content, bring reality and improve performance Putting what learnt in the class into practice	**Hands-on practical activities help to foster learning and process skills**
	Putting the theory in to practice	
	Conception and disposition towards practical activities: Learn best when exposed to hands-on activities Feeling positive about hands-on activities as learner' learn best and improve Hands-on motivates learners to learn Conception and disposition towards teaching osmosis Feeling good teaching osmosis because it's fun and easy even in under-resourced schools (T1, T3)	**Teachers conception and dispositions on incorporation of hands-on activities into teaching** **Teachers conception and disposition towards teaching osmosis using easily accessible resources**

	Osmosis is challenging to teach in schools where no resources are available; Osmosis concept give broader understanding on career related information (such as farmers)	
	Teachers' experience on hands-on activities Use of home and school based experiments or hands-on activities to teach the topic Teach alternatively to practical, and summarise the possible results Used prior knowledge to enhance learning Teachers experience in teaching osmosis Carry out hands-on activities about osmosis Give detailed definitions Use different resources to teach osmosis	Teachers' experiences on hands-on activities Teachers' experiences on hands-on activities Use of prior knowledge to teach science
	Use of easily available resources when mediating learning of osmosis	The use of easily accessible resources enhance learning
	Handing of materials is a challenge Inadequate materials to carry hands-on activities Misconceptions on the topic osmosis	Perceived challenges carrying out hands-on activities in schools ○ Insufficient knowledge and resources to mediate learning ○ Misconceptions about osmosis

Appendix 12: Formation of the episodes and themes

Codes	Categories	Episode	theme
	Greeting the participants	Greeting of the participants	
	Working together and interacting during the activity of developing model lessons Share how best to co-plan and co-develop for the lesson Share reflections Teacher and learners activities	Teamwork and interaction enable successful co-planning and co-development of the lesson Share reflections to improve how to co-plan and co-develop lessons	Teamwork facilitate effective lesson co-planning and co-development
	Use of prior and indigenous practices, fruits, vegetables Make sense of immediate environment	Use of prior and indigenous knowledge in lesson planning help teachers to teach learners in order to make sense of the use of their environments	Prior and indigenous knowledge enrich teaching and learning
	I can plan lessons well (T1 Positively impacted (T2) Open-up my mind (3) School with no resources can use easily accessible resources	Reflections on the development of model lesson. Oriented well on the use of easily accessible resources, even when teaching in rural area	The impact of co-planning
	Use the syllabus to plan Highlight important points to be learnt Curriculum expectation Co-planning Guiding introduction (use prior knowledge and existing knowledge) Planning the lessons well in advance	Use syllabus to plan lessons with all the supporting components Consider what the curriculum require or curriculum expectations Planning in advance very helpful	Enabling factors that facilitate development of model lessons

	Developing the lessons not an easy activities Materials not easy to find Experiencing materials default Not well prepared possess a challenge Not easy to improvise always	Materials not always available or enough; Insufficient exposure on lesson planning; Not easy to improvise Difficult to develop lessons (due to the lack of input.	constraints the teachers encounter when developing

Appendix 13: Formation of themes and theory

Episode	**Theme**	**Theory**	
		Literature	Conceptual/ theoretical framework
Greeting of the participants			
Interactions enable successful lesson co-development Share reflections to improve how to co-plan and co-develop lessons	Teamwork facilitate effective lesson co-planning and co-development		
Use of prior and indigenous knowledge in lesson planning help teachers to teach learners in order to make sense of the use of their environments	Prior and indigenous knowledge enrich teaching and learning		
Reflections on the development of model lesson. Oriented well on the use of easily accessible resources, even when teaching in rural area	The impact of co-planning and co-development of the lesson		
Use syllabus to plan lessons with all the supporting components Consider what the curriculum require or curriculum expectations Planning in advance very helpful	Enabling factors that facilitate development of model lessons		
Materials not always available or enough; Insufficient exposure on lesson planning; Not easy to improvise Difficult to develop lessons (due to the lack of input.	constraints the teachers encounter when developing		

Appendix 14: Semi-structured interviews

Type of interview: Semi-structured interviews
Type of questioning: Open ended questions with prompting
Codes:
T – teacher **R** – researcher **[….]** word/part missing
(cont.…) – continue **[word]** word not clearly captured
T1 T2 T3 T4
T1 & 2 – Teacher 1 and 2 (Example)
BTS – Both Teachers **S** – school **S1** – school 1

Navy/gold: Hands-on, minds-on, words-on activities
Yellow: Theory and practice: theory and practice
Dark yellow: Views or disposition
Purple: Experience and conception
Teal: Accessible resources
Orange dark: Prior knowledge
Red: Challenges

Research questions:
What are Grade 11 Biology teachers' experiences, conceptions and attitudes towards the use of easily accessible resources when mediating learning of osmosis?

Question 1: What do you understand by the term practical activity?

Code	Responses	Summary in points (categories)
T1	**T1**: Well! Aaaa… Practical activities I believe are activities that (aah) help learners to apply hands-on or mind-on, to make them understand the concept that require... practical activities it means that, the theory or whatever you learnt in the class you need to put into practice ed them to understand. So it is more of physical activities that, that help learners to master their contents of whatever specific topic they are doing.	• activities that help learners to apply hands-on or mind-on • Physical activities that help learners to master the content • Teach theory and practice • Use of process skills for experiments
T2	**T2**: Aaaa. **R**: tell me more on what you meant by putting what learnt into practice **T2**: Aaaa… learners they have to be given opportunity eee... to practice what they learn during the lesson, whereby they have to use the process skills they have learnt. **R**: Example? **T**2: Aaaa… for example, learners can be aaaaa… asked to conduct practical activities about diffusion. Whereby, they can be given aah… the teabags and put them in cold and hot water to assess how diffusion affected by the temperature.	

T3	**T3**: Practical activities are of aah... are those activities that are hands-on; things that would do or activities that require hands-on, or coming up with practicals that require touching or just hands on-activities.	
T4	**T4**: These are activities which require experiments. They require learners to do or learn by doing things [for themselves], by looking at the equipment or apparatus or other materials, just for them to understand the theory by seeing. **R**: Ok, thank you!	

Question 2: What are your views about incorporation of hands-on activities when teaching Biology?

Codes	**Responses**	**Summary in points (categories)**
T1	**T1**: I do that, it helps. You learnt best when you are exposed to materials by feeling or touching, but the fear is that some materials are too fragile, or possibly there are some safety measures that need to be put into consideration. So, exposing learners to these materials may not be… may not be very convenient with all the learners, but it really helps for them to apply hands-on approach. However, sometimes the materials are also not available, thus they are not applied. **R:** Ok, that's good	• Hands-on practicals enhance learning due to exposure • Challenges with the use of (practical) materials • Promote sense making • it is such a nice feeling to incorporate hands-on activities • improve performance
T2	Aaaa… I feel aaaa. learners should do more practical work, [there are] some of the learners learn best or well when they aah. see what happen	
T3	**T3:** Aaaa… it is such a nice feeling, because when you are including or incorporating hands on activities; learners tend to know much better; because when practicals bring reality in the classroom. And aaaa... and as you know some learners, have [learn differently] some learn better when they are doing practical and hands-on. Aaaa, and in that way it can improve the performance in the subjects, rather than learning and not practicing the content of the subject. **R**: …and how does this affect the performance of the subject or what did you say about this? I did not get you well there. **T3**: When I say it improve the subject…	

	R: Yes, you can tell me more about it. **T3**: Like I said, learners learn much better when doing practical, especially those or let me say most of them, they have interest in touching things around them. ...and when you are touching, your mind learns better, and if the learners practice and learn better, then at the end of the day, learners are getting marks. **R**: Ok, quite interesting.	
T4	**T4:** Aaaa, my feelings are quite good […]. Sometimes teaching learners the theory and would not real get what you are talking about. But, when you are putting in into practical, ...and... they tend to know what is that you are talking about. For example, on the topic now, that teaching them that osmosis is a movement of water molecules from region or area of higher water potential to the area of lower water potential. Now, they would think what is that, but if you show them how water moves in terms of using potatoes, and salt solution, they will understand what will happen to this plant cells, how they or what happen to when they take up water, and what happen to them when they lose water by looking at potato. **R:** Sooo… looking at the potato? Or structure? Or what do you mean by that? **T4:** You look at the structure, like for the cell if you put a cell in the salt solution, the cell loose water to salt solution. If it [is] put in pure water, of course water will move into the cell. But if you are using potato or onion, they will understand what will happen to the plant cells aaaa. when it is immersed into pure water (T4). **R:** Ok, thank you teacher 4.	

Question 3: How would you explain osmosis to the leaners to have a broader understanding of it?

Code	Response	Summary in points
T1	**T1**: Well, the process of osmosis it is actually a long, I looked it as a lengthened learnt process as they [leaners] it from junior grades. So, to broaden it I use the local available examples. For example, like... can look[ing] at the process of making tea: We have teabag and try to put in the transparent container, learners will observe once you put in the teabag into hot water, and then observe. I normally have two containers: one with hot water and another with cold water; throw the teabag into the containers at the same time; and learners will be observing what happens; and account why there are changes, or why those changes taking place; and relate to the topic (T1). **R:** Okay... and why may be do you use water of different temperatures? One with hot water and the other with cold water. **T1**: Eee... mhh, the ...the ...the main reason for different temperature it is also to relate to the rate of osmosis. How does temperature of water or of liquid helps to facilitate the process. **R**: Ok, that is very good	• learning from junior grades (Prior knowledge) • Use of the local available examples from their environment • Learners observe what is happening • Use of variety experiments; • Use of the demonstrations/ experiments can be fun and motivating • Home based practical activities • Provide definition •
T2	**T2:** Aaaa… it aaaa... learners love this topic of osmosis. It is fun to them, because they end up doing what they learnt during the lesson. It is kind of motivating them to learn more about the topic of osmosis.	
T3	T3: Yaaa… when I explain aaaa... the term osmosis to learners to make them understand much better, I try to include local examples. First of all, I define osmosis, because it is a passage of substances in and out of the cell. During osmosis, water moves, but not any other substance involved. And aaaa... if are I am not mistaken, in grade 9 we learnt that; we split that word into two, 'osmo' mean water, and "osis' means the process. So this means, is a process of water movement from higher concentration to low (T3). I then try to give local examples, of things that happening in their environments aaaa... just to mention, the example of when you are cooking. When you are cooking, let me […] for example, potato, animal cell, the potato, Hahah (laughed) I mean ' which is a plant cell. The potato it absorb water depends on whether the solution is hypotonic or hypertonic. So you tell them if you put a potato in the pure water which is not hypotonic with no solute in it, the potato take up some water, and water moves from high, where	

	no concentration inside. And you can even give them example that, or can even practice it at home: you have potato, and put it in different solutions (hypotonic and hypertonic) and observe after the day, and see what will happen. Meaning, learners can also practice at home (T3).	
T4	**T4**: Mhh… I would explain, it is a movement of water molecules from the region of higher water potential to the region of lower water potential aaaa... through the partially permeable membrane **R**: when you are teaching it now, do you also […]. Ok, that is how you define it eee... but for the learners to have a broader understanding, how do you explain to them? **T4**: Aaaa... I would rather say, in terms of plants how they absorb water; they absorb water. Because, in the soil, there is higher water potential that in the roots. This would force water to move from the soil into the roots and absorbed by root hair cells, so what will also force water from the soil into roots and absorbed by root hair cells. So that will also force water from the roots up there through xylem vessels. It will now be higher water potential in the roots than other parts. **R**: That's good… do you use any other examples, apart from the plant cells? **T4**: Aaaa… we just link them to the prior knowledge of diffusion, for example, how particles move from the region of higher concentration to the region of low concentration. **R:** Ok, that's good.	

Question 4: What are your general views of teaching osmosis as a practical concept in the under-resourced schools?

Code	Responses	**Summary in points**
T1	T1: Mhh… it applies no pressure to me. Because even the school is under resourced, it is easy to demonstrate it, because, we …it happen always, and looked it as everyday process. You can even ask one of the learners, learners have sprays in their bags and ask who is having a spray or perfume here; and a learner can say yes, I do have. Then ask, can you please …say… spray, and close the door and windows. Then ask the learners, who is in another corner, what observation are you making in the class? From there, can tell, no, I can smell the perfume she applies. Now, the question is that, how that perfume reach you on the other side if you are that far? And then you relate. Yaaa… but that one is more of *diffusion*; I just have to pay particular attention on the definition that I give to the learners (T1). R: Ooo… ok, R: (cont.…) ok... so the other question might be more or less related to what you already gave. Aaaa… but you may add some other examples. It says, have you ever used easily accessible resources to teach osmosis in your class, like… for the learners to catch up or to get proper concepts to enable define it. And if you have used any, please provide reasons and may be examples of those materials. (*answers provided under the next question)*	• Easy to demonstrate even in under resourced schools • Easy concept to teach when using different materials especially easily accessible resources • Challenging and difficult to understand and teach if no resources or materials available. • Use of easily accessible resources improve learners' understanding • Improvise to make teaching perfect
T2	**T2**: Aaaa… it is easy to teach this topic because, we can use different materials that can be used to demonstrate aaaa… the process of osmosis. Like... whereby you use potato and salt water, or potatoes and …mhh… sugar solution and, I know that, everyone is able to get a potato and use (T2). **R**: So they are easily accessible? **T2**: Yes, they are easily accessible and learners are even familiar with it, they know what is a potato, so, the potato {represents} a plant cell. So they will understand well when they are using materials which are used or which are found local. **R:** Thank you teacher 2 **R:** (Cont.…) have you ever used any easily accessible resources in you class when you are teaching osmosis?	

	If yes then you provide reasons and examples of those materials. I know you have mentioned some already but you can always add more or explain more on them. (*answer provided on the next question*)	
T3	**T3:** In under-resources schools? **R:** Yes, the schools with no enough resources… **T3:** Under-resourced... ooo… it is a bit a challenge, but as a teacher you have always to improvise. You just have to find a way on how to do practical on that; instead of leaving the topic unpractised. You just have to check into your environment and try if you can get some resources. …And I think, it is a challenge because sometimes the most appropriate …aah… tools are not available or things that you are going to use or, so to say, are not available and sometimes it will be difficult for the learners to understand them (T3). But if we were having the prescribed or the most widely used tools it is easier for the learners to understand. It is quite a challenge. **R:** Mhh… very good!	
T4	**T4:** Aaa… my feeling is that, …aah… osmosis is not something that difficult to understand, but in a school where there are no resources is a challenge, I would make means to look for materials from the surroundings. Like in terms of things like, we are talking of salt solution here. It is just something you can make yourself; pure water and just a potato or onion, just for them to understand. My feeling towards this practical topic is quite good comparing to other topics (T4). R: So, meaning that, …are you saying that, it would not possess much challenge when teaching it in under-resource schools? T4: Nooo! It will not possess any challenge even if the school is not having materials. There are no real challenges towards this. Like in terms of, like …we have a school garden, and then you just have to teach them to understand, why are we watering our garden for example? So, …and some of the learners they have that [concept] of saying, they like watering to the leaves as if the leaves are the ones that taking up water. Just you need to make them understand that, what absorb water is the roots, and what cause this is the osmosis. Water is	

	moving from the soil where there is high concentration to the roots. …yes (T4)! R: ok, thank you! …those are some of the examples… very interesting… R: (Cont.…) have you ever …although you have already mentioned some, have you ever used any easily accessible resources? Just give some examples, when you are teaching osmosis, and provide reasons, or you can tell me more, because you already mentioned some. (*answers to be provided in the next question*)	

Question 5: What easily accessible resources you may use to teach osmosis in your class?

Code	Response	
T1	**T1:** Okay, one of the examples, as I mentioned earlier is for making tea, using different water temperature. The other one, that I normally use is looking to the effect of osmosis on plant cells and animal cells, where we …but I have not try the ones in animal cell. In plant cells we normally use potatoes, because potatoes are easily obtained locally. … and potatoes with either salt solution or sugar solution, and observe, you see what happen to potato cells afterward. …And you can able to describe any changes within the potato […] because of osmosis, and cells are actually get ware from outside […]. **R:** Ok, that is good, and then about animal cell, you said? **T1:** I said I haven't tried it. **R:** Now, how do you explain it to learners to make them understand, even theoretically? **T1:** Theoretically, we …I try to summarise the practical work for them. Try to describe, I try to design a simple experiment, if were allowed to use example of liver cell (fresh one). We design the practical with the aim of the activity, materials, procedures and what	• Using local resources or examples (such as potatoes, onion, salt, sugar) • Summarise practical work without doing the practical activities • Design experiments • summarise it without experiment • Using of specific examples to teach osmosis

	is likely to be observation without carrying the practical (T1). **R:** Are you doing it like alternatively? **T1:** Just explaining without practical with liver cells.	
T2	**T2:** Yaaa! Yes, I have used them before and e materials that I have used, is a potato that I t into strips and these strips …and these strips ut them into equal lengths and equal widths, d then we put them into different solutions. nd put three into concentrated solutions (that is solution made up of water and sugar), and her three put them in dilute water, then left for minutes. After 30 minutes, we take them out, d take the three from the concentrated lutions. We measure the lengths to see if they ined water or if they lose water. We also and do the reporting. And we also take the ree strips of potatoes in the pure water or stilled water, and we measure …we measure e lengths and the width, we have to touch them know how they feel. And then, after getting r results, we make conclusion (T2). **R:** Waaw, that's very interesting…	
T3	**T3:** Yes, I did (interrupting) **T3:** (Cont.…) yes, I already did that practical, and I used aah… we use resources such as potatoes (fresh one) as one of the materials, and we used water with different concentrations, and we also used salt (just the cooking ones) for solute. And then, iyaa… we have different solutions depends on the amount of salt. ...where in one container we put salt and in the other on salt. **R:** is there any other example that you have used apart from the potato? **T3:** But you are doing osmosis? R: Yaaa! Or are only that one you have used? **T3:** Yaaa… we only used that one for potatoes, and others are just examples	

	…general examples that can happen in the human body. For example, I can even say when you are bathing, or when washing dishes, and you have spent quite lot of time there (T3). After that, your hands are somehow like swollen, meaning that again the water had played some roles regarding the definition of osmosis or concerning the meaning of osmosis. Because, if you check or if you touch water for long time your hands after that are swollen, meaning that, I can conclude that water moves from higher concentration to low concentration, it is like [basting] from the container (where you are. Like, …it is just like when you are in the kitchen washing dishes after that differ from person to person (T3).	
T4	**T4:** No, no, no! because, …aah… …aah... because we are not really try to think out of the box and come up with other than what we have been using; of salt solution and pure water, sometimes we also using only sugar solution, aaa… onions and potatoes as I stated. That's all. **R:** Ok, that's good	

Question 6: What relevance does the concept osmosis has to the world view?

Code	Responses	Summary in points
T1	**T1:** Definitely, it has a role to play. It aah... if you look at it, people, …let me say, learners they are studying it for future careers. Some of them are likely to be farmers, and when they become farmers, they should be able provide reasons; when plants behave in such ways in this specific conditions. **R:** Exactly! **T1** (Cont.…) how can I feed my plants with minerals or ions? How much I would have applied because of up-take? Remember these ions are found, …ions actual dissolve in water; …ions dissolve in water, and when	• Envisioned the future • Helping to understand other processes such as osmoregulation, dehydration, absorption, diffusion, wilting, respiration, dissolving, photosynthesis • very crucial because it happen every day in our environments

	water moves from the region of high concentration, [which is the ground] , that is osmosis (T1). In terms of …aah… …aah… mammals or animas we are looking at dehydration process. Cells when you have dehydrated, what basically happen? Means, your cells are running out of water, when the water gets out, probably is because of osmosis. **R:** Meaning, it gives also a broader context in other areas, like when somebody is dehydrated, what could be the case; when plant wilts, what could be the case, and so on… **R:** (Cont.…) ok, meaning …to you, it is an important process? **T1:** It is an important process that you cannot turn the eye on it. **R:** That's good! Do you think it can also be incorporated into the revised curriculum? **T1:** Yaaa! It must be part of the curriculum.	
T2	**T2** Yaaa, I think it is relevant to the worldview because, this is …aah… this process it take place in our everyday life activities. **R:** Interesting! Tell me more about it. **T2:** More about it? **R:** Yes, how does it important in our daily life? **T2:** In our daily life situation …for example, when you are cooking… **R:** Good example, what happen when you are cooking? **T2:** Aaa, when you are cooking cabbage aah… or when cooking vegetable aah, you are [break], especially carrots, you need to wash them and peel them, and then put them in water. You discover that, in the container	

	where put pieces of carrots you see the colour of the carrots in water; showing that osmosis have taken place. **R:** You mean, now the dye or water moves from the solution into the carrots... **T2:** [no further comments made] **R:** (Cont.…) okay, thank you so much	
T3	**T3:** Any relevance or importance? **R:** Yaaa! **T3:** I think so, yaaa… the concept osmosis is very crucial because it happen every day in our environments and …aaa… it is important for someone to understand on what happens in our cells and how can we take care of … take care of our bodies regarding the definition. Sometimes you can even just find a person …aaa… doing things on her body without knowing that things can happen or this can happen. But if a person know the definition of osmosis, a person can also know what will really happen; I think it is relevant to the world (T3). **R:** and in the body? What you meant with referral to the body for the example you gave? **T3:** Oooo, there I mean, as I already gave the example of touching water, and some people can bath for a loooong… time, and somewhere somehow has an effect. And, like as we studied the animal cells, and like as we studied the animal cells, and we are also animals have no cell wall. If anything happen your cells are capable of burst, only that cannot just happen within a minute. **R:** Exactly, so you are thinking it should also be incorporated into the revised curriculum? **T3:** Exactly, it should not just [interrupted] or left out but it must be included in the revised curriculum.	

	R: Ok, Thank you so much	
T4	T4: I am feeling that, it should be part of the new curriculum; and then the grade 8 it is already part of it. We are teaching it in grade 8. It is a very important topic, and it is very broad and, because when it comes to water; all living things they need water. It is a solvent and it helps will all chemical process like in terms of respiration although water is given off. But like for photosynthesis will help plants to get minerals. Minerals, we are talking of Nitrogen that taken as nitrates for formation of chlorophyll that is still needed for photosynthesis. …yaaa (T4)! **R:** Ok, thank you, it is quite interesting teacher 4	

7. Do you have anything else you would like to share with me?

Codes	Responses
T1	T1: Yes! …aaa... I should just indicate that it was nice to have such interview, it really open up my views on osmosis. I usually view it based on the syllabus but you made me think that, well especially on that questions on the worldview, how people view it in the world. I somehow neglected that, so now it really open-up a certain angle for me, and and…and it also motivates, it encourage me to do practicals based on. I think osmosis should be taught through practicals for the learners to understand the concepts. R: Thank you so much T1: Welcome Ms.
T2	T2: Aaa… I would like to see you again to do with use the practical about transpiration. R: Ok, do you think it is also a concept that you think need more practical? T2: Yes, …which is a bit so challenging to learners, and sometimes to the teachers… R &T2: both laugh…. R: Thank you very much teacher 2, all the best T2: Bye Bye!!!
T3	T3: Iyaa! I would like to say that, if a teacher find himself or herself in under-resourced school, should not leave the practical out with the reasons in mind that, no resources , I cannot practice this. The only [way] is to try by all means to improve, look around in your environments and try if you can find anything useful and thing that suitable for or relevant to that activities, rather than just leave it out. And, the other thing is that, we need teachers to try to explain terminologies, like sometimes you are explaining to learners terms like hypertonic and hypotonic, and you talk about osmosis If you ask them what will happen to the plant cell in the hypotonic solution, but you teach That hyper is less, hypo is more. Then they will say, water will move if you place hypotonic, water will move out; but that is opposite. The hypo, the less, which is there re not water it is solute. So the concentration is not for water nut solute (T3). R: Thank you so much

	T3: You are welcome mem.
T4	T4: Iyaa… like in our schools we do not have materials or resources to carry out these practical activities. sometimes, we cannot do anything just to teach theory. Some of the things, sometimes we have but they are not enough. Like sometimes our schools we have things like chemicals like ammonia. Ammonia solution and other chemicals that we have for other practicals like diffusion, bur for others …aaa… Noo, things like photometers. R: Thank you so much for contributing R: Thank you Ms Nangolo

- **Sub-theme emerged:** (presented together with teachers' view on teaching osmosis)
-

Gold/navy: Hands-on, minds-on, words-on activities
Yellow: Theory and practice: theory and practice
Dark yellow: Views or disposition
Purple: Experience and conception
Teal: Accessible resources
Orange dark: Prior knowledge
Red: Challenges

Research questions: What are Grade 11 Biology teachers' experiences, conceptions and attitudes towards the use of easily accessible resources when mediating learning of osmosis?

Forming of subcategories, categories, subtheme and themes (Semi-structured interviews)

Sub-categories	Categories	Sub- themes	Theme
Practical activities I believe are activities that (aaa) help learners to apply hands-on or mind-on (T1) So it is more of physical activities that, that help learners to master their contents of whatever specific topic they are doing (T1). whereby they have to use the process skills they have learnt **(T2).** For example, learners can be aaaaa… asked to conduct practical activities about diffusion. Whereby, they can be given aaa… the teabags	Are activities that apply hand-on or minds-on Physical activities which uses process skills to master the content, bring reality Activities that require experiments and require learners to learn by doing Practical activities	Hands-on activities requires a use of process skills to master the content, bring reality and improve performance Putting what learnt in the class into practice	**Hands-on practical activities help to foster learning and process skills**

and put them in cold and hot water to assess how diffusion affected by the temperature **(T2)** Practical activities are of aaa... are those activities that are hands-on; things that would do or activities that require hands-on, or coming up with practicals that require touching or just hands on-activities **(T3).** **T4**: These are activities which require experiments. They require learners to do or learn by doing this (T4). learners tend to know much better; because when practicals bring reality in the classroom (T3) learn better when they are doing practical and hands-on. Aaaa, and in that way it can improve the performance in the subjects, rather than learning and not practicing the content of the subject (T3) learners learn much better when doing practical, especially those or let me say most of them	improves performance Putting what learnt into practice to improve the understanding in the subject		
.. practical activities it means that, the theory or whatever you learnt in the class you need to put into practice (T1) learners they have to be given opportunity eee. to practice what they learn during the lesson (T2) by looking at the equipment or apparatus or other materials, just for them to understand the theory by seeing […]. Sometimes teaching learners the theory and would not real get what you are talking about. But, when you are putting in into practical, ...and... they tend to know what is that you are talking about (T4)	Putting what is learnt into practice To practice what they learn in the class Using practical activities improve understanding	Putting the theory in to practice	
You learnt best when you are exposed to materials by feeling or touching (T1)	Conception and disposition	Conception and disposition towards	**Teachers conception and dispositions on incorporation**

exposing learners to these materials may not be… may not be very convenient with all the learners, but it really helps for them to apply hands-on approach.(T1) I feel aaaa... learners should do more practical work, [there are] some of the learners learn best or well when they aaa... see what happen (T2) it is such a nice feeling, because when you are including or incorporating hands on activities (T3) they have interest in touching things around them. ...and when you are touching, your mind learns better, and if the learners practice and learn better, then at the end of the day, learners are getting marks (T3). my feelings are quite good (T4) **T2:** Learners love this topic of osmosis. It is fun to them, because they end up doing what they learnt during the lesson. It is kind of motivating them to learn more about the topic of osmosis **T1**: … it applies no pressure to me. Because even the school is under resourced, it is easy to demonstrate it, because, we …it happen **T2**: Aaaa… it is easy to teach this topic I think, it is a challenge because sometimes the most appropriate tools are not available or things that you are going to use or, so to say, are not available and sometimes it will be difficult for the learners to understand them **(T3).** **T4:**my feeling is that, osmosis is not something that difficult to understand, but in a school where there are no resources, My feeling towards this practical topic is quite good comparing to other topics (T4).	towards practical activities: You learn best when exposed to materials Materials may not convenient to all learners, but really help them to learn Feeling that learners should do more practical activities to learn best It is nice feeling and learning best when incorporating hand-on Teaching learners practically motivate the learners to learn more about osmosis Conception and disposition towards teaching osmosis Feelings quite good; Like the topic osmosis, it is fun to the learners	practical activities: Learn best when exposed to hands-on activities feeling positive about hands-on activities as learner' learn best and improve Hands-on motivates learners to learn Conception and disposition towards teaching osmosis Feeling good teaching osmosis because it's fun and easy even in under-resourced schools (T1,T3) Osmosis is challenging to teach in schools where no resources are available;	**of hands-on activities into teaching** **Teachers conception and disposition towards teaching osmosis using easily accessible resources**

T4: Nooo! It will not possess any challenge even if the school is not having materials. There are no real challenges towards this learners they are studying it for future careers. Some of them are likely to be farmers, and when they become farmers they should be able provide reasons (T1) **T1:** It is an important process that you cannot turn the eye on it. **T2** I think it is relevant to the worldview because, this is …aaa… this process it take place in our everyday life activities. **T3:** I think so, yaaa… the concept osmosis is very crucial because it happen every day in our environments and …aaa… it is important for someone to understand on what happens in our cells and how can we take care of … take care of our bodies **T1**: Yes! …aaa... I should just indicate that it was nice to have such interview, it really open up my views on osmosis. I usually view it based on the syllabus but you made me think that, well especially on that questions on the worldview, how people view it in the world. I somehow neglected that, so now it really open-up a certain angle for me, and and…and it also motivates, it encourage me to do practicals based on. I think osmosis should be taught through practicals for the learners to understand the concepts **T2**: Aaa… I would like to see you again to do with use the practical about transpiration **T3:** Iyaaa! I would like to say that, if a teacher himself or herself in under-resourced school, sh not leave the practical out with the reasons in r that, no resources. I cannot practice this	Easy to teach and demonstrate even in under-resourced schools (T1) Challenging to teach when no appropriate materials available (T3) Osmosis is not difficult to understand, when no resources (T4) My feeling quite good to teach osmosis comparing to other topics Provide future plans and broader understanding (worldview)	Osmosis concept give broader understanding on career related information (such as farmers)	
if you show them how water moves in terms of using potatoes, and salt solution, they will understand what will happen to this plant cells (T4)	Teachers' experience on hands-on activitites		

T4: You look at the structure, like for the cell if you put a cell in the salt solution, the cell loose water to salt solution. If it [is] put in pure water, of course water will move into the cell **T1**: Well, the process of osmosis it is actually a long, I looked it as a lengthened learnt process as they [..leaners..] it from junior grades. I define osmosis, because it is a passage of substances in and out of the cell. During osmosis, water moves, but not any other substance involved (T3) …example, potato, animal cell, the potato, haaahaah (laughed) I mean ' which is a plant cell. The potato it absorb water depends on whether the solution is hypotonic or hypertonic (T3) And you can even give them example that, or can even practice it at home: you have potato, and put it in different solutions (hypotonic and hypertonic) and observe after the day, and see what will happen. Meaning, learners can also practice at home (T3). **T4**: Mhhh… I would explain, it is a movement of water molecules from the region of higher water potential to the region of lower water potential aaaa.. through the partially permeable membrane **T4**: Aaaa... I would rather say, in terms of plants how they absorb water; they absorb water. Because, in the soil, there is higher water potential that in the roots. we can use different materials that can be used to demonstrate aaaa… the process of osmosis You just have to find a way on how to do practical on that; instead of leaving the topic unpracticed. You just have to check into your environment and try if you can get some resources.(T3)	Home and school based experiments Give examples when teaching Finding a way how to teach a topic Teaching theory and summarize possible results or outcome Explain terminologies Use of prior knowledge Teachers experience in teaching osmosis Sowing the learners how water moves from using a potato Observe the plant immersed in hypotonic and hypertonic solution Explain to the learners what osmosis all about Use different materials used to demonstrate osmosis I try to design a simple		

But if we were having the prescribed or the most widely used tools it is easier for the learners to understand (T3) The other one, that I normally use is looking to the effect of osmosis on plant cells and animal cells, where we …but I have not try the ones in animal cell (T1) Theoretically, we …I try to summarise the practical work for them. Try to describe, I try to design a simple experiment, if were allowed to use example of liver cell (fresh one). We design the practical with the aim of the activity, materials, procedures (T1) , I have used them before and the materials that I have used, is a potato that I cut into strips (T2) And put three into concentrated solutions (that is a solution made up of water and sugar), and other three put them in dilute water, then left for 30 minutes (T2) We measure the lengths to see if they gained water or if they lose water. We also …and do the reporting (T2) we measure the lengths and the width, we have to touch them to know how they feel. And then, after getting our results, we make conclusion (T2). **T3:** Yaaa… we only used that one for potatoes, and others are just examples …general examples that can happen in the human body. **T3:** (Cont…) yes, I already did that practical, and I used aaa… we use resources such as potatoes (fresh one) as one of the materials, In terms of …aaa… …aaa… mammals or animas we are looking at dehydration process. (T1) Means, your cells are running out of water, when the water gets out, probably is because of osmosis. (T1)	experiment theoretically (if were allowed to use example of liver cell (fresh one). We design the practical with the aim of the activity, materials, procedures Explain on how dehydration occurs		

T3: Oooo, there I mean, as I already gave the example of touching water, and some people can bath for a loooong… time, and somewhere somehow has an effect Try to explain terminologies, like sometimes you are explaining to learners terms like hypertonic and hypotonic (T3) (T4)we cannot do anything just to teach th Some of the things, sometimes we have but the not enough. Like sometimes our schools we hav			
to broaden it I use the local available examples (T1) T3: Yaaa… when I explain aaaa.. the term osmosis to learners to make them understand much better, I try to include local examples. I then try to give local examples, of things that happening in their environments aaaa.. just to mention, the example of when you are cooking. When you are cooking (T3) use potato and salt water, or potatoes and …mhhh… sugar solution and, I know that, everyone is able to get a potato and use (T2) **T2**: Yes, they are easily accessible and learners are even familiar with it, they know what is a potato, so, the potato {represents} a plant cell. So they will understand well when they are using materials which are used or which are found local. **T3:** Under-resourced... ooo… it is a bit a challenge, but as a teacher you have always to improvise I would make means to look for materials from the surroundings. Like in terms of things like, we are talking of salt solution here. It is just something you can make yourself; pure water and just a potato or onion, just for them to understand(T4)	Using local available resources; things that happen in the environment Using local examples: ○ when cooking ○ when bathing or washing	Use of easily available resources when mediating learning of osmosis	

…we have a school garden, and then you just have to teach them to understand (T4) In plant cells we normally use potatoes, because potatoes are easily obtained locally. (T1) The only [way] is to try by all means to improve, look around in your environments and try if you can find anything useful and thing that suitable for or relevant to that activities, rather than just leave it out (T3)			
some materials are too fragile, or possibly there are some safety measures that need to be put into consideration (T1) However, sometimes the materials are also not available (T1) T4: Iyaa… like in our schools we do not have materials or resources to carry out these practical activities. sometimes, We have teabag and try to put in the transparent container, learners will observe once you put in the teabag into hot water, and then observe. I normally have two containers: one with hot water and another with cold water; throw the teabag into the containers at the same time; and learners will be observing what happens; and account why there are changes, or why those changes taking place; and relate to the topic (T1). So this means, is a process of water movement from higher concentration to low (T3) You can even ask one of the learners, learners have sprays in their bags and ask who is having a spray or perfume here; and a learner can say yes I do have. Then ask, can you please …say… spray, and close the door and windows. Then ask the learners, who is in another corner, what observation are you making in the class? From there, can tell, no, I can smell the perfume she applies. Now, the question is that, how that perfume reach you	Handing of materials is a challenge Inadequate materials to carry hands-on activities Misconceptions on the topic osmosis		

on the other side if you are that far? And then you relate. Yaaa… but that one is more of diffusion; I just have to pay particular attention on the definition that I give to the learners (T1). Water is moving from the soil where there is high concentration to the roots. …yes (T4) and we used water with different concentrations (T3) After that, your hands are somehow like swollen, meaning that again the water had played some roles regarding the definition of osmosis or concerning the meaning of osmosis. Because, if you check or if you touch water for long time your hands after that are swollen, meaning that, I can conclude that water moves from higher concentration to low concentration, it is like [basting] from the container (where you are. Like, …it is just like when you are in the kitchen washing dishes after that differ from person to person (T3). … ions actual dissolve in water; …ions dissolve in water, and when water moves from the region of high concentration, [which is the ground] , that is osmosis (T1). **T2:** Aaa, when you are cooking cabbage aaa… or when cooking vegetable aaa, you are [break], especially carrots, you need to wash them and peel them, and then put them in water. You discover that, in the container where put pieces of carrots you see the colour of the carrots in water; showing that osmosis have taken place.			

Appendix 15: Workshop Programme

	Days	Activities	Concepts	Theories
Workshop 1 (Research Orientation)	One day in the week	• Introduction to participants • Overview of the research project and ethical issues involved. • Group discussion: sharing of teachers' experiences, conceptions and attitudes towards the use of easily accessible resources when mediating the learning of osmosis.	Social interactions	Social constructivism Theory
Workshop 2: Demonstration of the practical activities using easily accessible resources	One day in the week	• Teachers' engagement and become part of the demonstration of activities and work as a team Example of activities: Activity 1: *Effect of osmosis on plant cell* *(**using a potato/ oranges/ apples):*** o Determine water potential of the tissue o Permeability of the cell o Materials: *Potato tuber,* *improvised beakers* *pre-boiled water (A)* *salts* *feeding bottles/ measuring cylinders, Test tubes, cutter/ knife/ blade, household jags, ruler, Stop watch, Tiles* Activity 3*: The effect of hypotonic and hypertonic solution to animal tissue* **(using deshelled eggs)** Materials: *Deshelled egg, sugar/ sugar, distilled water, vinegar* • Discuss findings of activities and able to prove if osmosis has taken place. • Discuss whether they find the exercise useful or not	Practical activities	
Workshop 3: Co-planning	1 day/week	• Group discussion and co-plan and develop model lessons • Two model lessons will be co-developed	• Social interactions • Shift in ZPD	
Implementation of model lessons		• Each teacher will implement the model lessons in their own class on different days. • Only two model lessons per teacher that will be observed	Mediation of learning	
Workshop 4: Reflections	1day/week	• Reflections – sharing of experiences (this will be done after the implementation of the model lessons)	Social interaction, learning	

Appendix 16: Workshops

Workshop 3 - STORY FROM THE WORKSHOP

Step 1:
After greeting the participants, the aim and objectives of the workshop 3 was shared with the participants:

Aim of the workshop 3 was;

- to share experiences on how best we use resources to develop lessons
- to share how best we can use the resources in our surrounding to teach some of the complicated concepts such as osmosis.
- discuss and co-plan and develop model lessons.

Step 2

After sharing the aims of the workshop, the participants used the syllabus to analyse the specific information. Such analysis was only made to pin point important aspects that worth in making contribution to the development of the model lessons.

Activity: Analysis of the syllabus
Make use of the Extract from MoE, NSSC Ordinary Level, 2010

Syllabus extract

2. RATIONALE

Learning experience in the natural scientific area aims at increasing the learners' knowledge and understanding of the physical and biological world of which they are a part. This includes understanding how people use the natural environment to satisfy human needs, and how the environment may be changed in ecologically sustainable ways. Critical thinking, investigating phenomena, interpreting data, and applying knowledge to practical (experimental and investigative) skills and abilities are essential to understanding the value and limitations of natural scientific knowledge and methods, and their application to daily life. The application of scientific knowledge and attitudes to health is of special relevance for the individual, the family, and society as a whole.

The overall aim of the syllabus is to equip learners with the necessary knowledge, skills and attitude that will enable them to enter tertiary education or the world of work.

TOPIC	GENERAL OBJECTIVES Learners will:	SPECIFIC OBJECTIVES Learners should be able to:
4. Passage of substances		
4.1 Diffusion	• Know diffusion as the movement of molecules	• define **diffusion** as the movement of molecules from a region of their higher concentration to a region of their lower concentration down a concentration gradient • describe the importance of gaseous and solute diffusion, and of water as a solvent
4.2 Osmosis	• Understand the concept of osmosis as the movement of water molecules across a partially permeable membrane	• define **osmosis** as the passage of water molecules from a region of their higher water potential to a region of their lower water potential , through a partially permeable membrane • describe the importance of osmosis in the uptake of water by plants • describe the effects of osmosis on plant and animal tissues
4.3 Active transport	• Realise the importance of active transport in plant and animal cells	• define **active transport** and discuss its importance as an energy-consuming process by which substances are transported against a concentration gradient, e.g. ion uptake by root hairs and uptake of glucose by epithelial cells of villi

The two extracts were used to guide participants during the development of the lessons, by analysing what is expected to be achieved by the learners in the activities.
The first part of the extract was used to enlighten the participants about curriculum expectations that prepare the learners to achieve the learning goals. The second part of the extract was used to identify the learning area that learners should master i.e. learning objective and specific objectives.

Step 3: After analysis, the lessons plans format was prepared to guide how much to be covered during the presentations. The following document were also used to guide with regarding the lessons presentations:

- the syllabus NSSCO Biology
- lesson plan format (used the school format)
- textbooks / any resource books
- materials (resources) for hands-on activities
-

The lesson planning was co-planned by the teachers, using the format which was adapted from the MoE, Subject Policy (Natural Science and health Education, Life Science and Biology) (2010).

The lesson plan had the following components:

1. Basic information section:

- Teachers' name(s); Subject; Grade; Theme; Topic; Date; lesson duration
  2. Learning objectives: At the end of the lesson learners should be able to:
  3. Basic Competencies (Specific Objectives): Learners should be able to:
  4. List of materials
  5. Monitoring of homework and Introduction:
  6. Presentations: teachers and learners activities:
  7. Assessments
  8. Consolidation:
  9. Reflection:

Teachers completed the first three component of the lesson plan, and started the discussion with component 4.

WORKSHOP 2 Transcripts

Introduction:
The introduction had two components:

- Teacher would introduce the lesson based on the previous lessons that related to osmosis. For instance; asking anything related to the movement of substances such as diffusion (existing knowledge)
- A teacher to introduce the lesson that pre-tests the learners' prior knowledge.

As part of introduction, teacher planned to use following indigenous fruits to arouse learners' **prior knowledge**. The use of indigenous fruits were related to the food preservation which including drying/ storage

Sources: Learners would source the lesson with various fruits (requested well in advance) on voluntarily basis. The reason was for the learners to make sense of their environments, and the resources around them.

Extract as part of discussion on the prior knowledge:

T2: We need to discuss what to include in the prior knowledge (introduction)

T3: I think we need local examples. Ooo! How now?

T2: Local things?

T3: may be asking them how and why they dry fruits?

T2: Yaaa, may be eembe…

Although teachers wanted to continue with othe examples, they returned to indigenous practices; as shown in the extract that follow:

T2: may be we also need to use local examples […] like [….]

T3: For example, especially okaana to ka kosho takakalamo efimbo ile momeva, like… eshi taka kadja omo okashendja nai (means, if you bath a baby for long, the body will look changed)

T2: Iyaaaa… odo example twa pumbwa okulongifa odo (means, those are the examples we need to use, ref. to teaching).

T2: Cont.. anuwa nuundjembele (even the raisins), if you put them in water.

T3: o red meat nayo oiwa nee okulongifa (even its good to use the red meat)

T2: naame oyo nda dilaadila, the problem it is contagious. So meni lombelela mwinya omuna o higher water potential then the out side surfaces, so omeva otaadimo meni. (I also thought of it (meat), but the problem is that it is contagious. So inside the meat there is higher water potential that outside surfaces, so water will move out).

R: if you want to make it more even exciting you can do it at home and you take a picture of how it looks like after put the salt. Very good example to use, and show the learners pictures.

Materials use for the lessons: the materials to be requested from learners well in advance prior to the lessons on voluntarily basis:

List of traditional materials

Materials	**Where obtained**
Dried/ fresh Vegetables: *eenyandi, eembe (berries), eendunga (palm fruits),*	Learners to supply (voluntarily)
Dried fruits/ fresh: *omakunde (beans), mahangu (millet), oilyavala (sorghum)*	Learners to supply (voluntarily)

shows the list of accessible resources used

Materials	**Where obtained**
Boiled/ Distilled water	Previously boiled (to be supplied by the teacher)
Knives	Teachers to source them
Rulers (transparent)	Available in schools (to be supplied by the teacher)
Table salt	From the kitchen / ask learners to bring from their homes
Potatoes	From the school garden (teachers supply)

Vinegar	From the local mini-markets/ shops to be prepared by the teacher)
Spatula	teachers to bring tea spoons / table spoons from home
feeding bottles	Ask learners to bring pre-used containers from their homes
using cut bottles / beaker	Collect empty cool-drink bottles from the nearby cucashops/ homes/ filling stations
Eggs	Asked each learner to bring one egg from home (most of the learners were from rural areas where most of the parents keep chickens) especially from Brave Secondary School
Weighing scale	Conventional (borrowed from neighbouring school)

Step 4: the development of the model lessons started and was done as a collective task, where all the participants took part.

Picture taken during the lesson development

Presentation: Learners and teachers' activities listed (Sample of lesson was used) (see the Appendix)

Consolidation: learners discussed the findings

Teachers reflected to share their experiences on the workshop as follow (see the attached reflections).

Appendix 17: Activity 1 Osmosis using potato

Appendix: Activities

Activity 1: Osmosis with Irish Potato

You are provided with the following materials:

1. Fresh potato tubers
2. Improvised beakers / cut cool drink bottles
3. Pre-boiled water
4. Feeding Bottles / measuring cylinders
5. Cutter/ knife/ blade
6. ruler
7. stirring rod/ pen bottles (transparent)
8. Watch/ Stop watch/ cellphones
9. Tiles (previously used house tiles/ lab benches)

Instructions/ depends on any possible preparation

1. Put 150 ml of distilled water in the test-tube / beaker, label it A / depends;
2. Put 150 ml of salt solution in the test-tube / beaker , label it B/ depends;
3. Take a potato tuber;
4. Cut two strips of 50mm (length), 10mm (width) and 5 mm (height) from the same tuber;
5. Cut the ends of the strips to remove the skin cover;
6. Insert / place the strip into water and the other one in salt solution;
7. Observe and measure each strip at interval of 5 minutes;
8. Record the change in the table;
9. Observe for 20 minutes.

ACTIVITY 1: WORKSHEET

Complete the worksheet

1. (a) Record the findings in this table.

Time/min	Potato strip length (mm)	
	Strip A(mm)	Strip B (mm)
0	50mm	50mm
5		
10		
15		
20		

Table well completed with reasonable results ...=2 marks

(b) Plot the graph (Bar graph) using the data in the table (a).

[5]

(c) Describe your results [3]

2. Explain why it is necessary to remove the skin cover at end of each strip? .[2]
3. At the end of the experiment touch and observe the potato strips and write your observation. [2]
4. With reference to the experiment outcome, define the term osmosis. [3]
5. Suggest what could be done better to improve the results of the experiment? Give **three** points. [3]

Appendix 18: Activity 2: Osmosis using eggs

Activity 2: Using an egg

The effect of hypotonic and hypertonic solution

Demonstration of osmosis using an egg

Materials

1. Raw eggs
2. salt solution/ salts
3. pre-boiled water
4. Vinegar (with Acetic Acid)
5. Other materials as listed in the table

Procedures:

1. Immerse raw eggs in vinegar;
2. Within a second you see bubbles form this bubbles are carbon dioxide that produced when acetic acid break down the egg shell, kept in the vinegar for 24 hours. Then you have a semi permeable membrane from the hard outer shell to conduct the experiment;
3. Wash off the vinegar with water;
4. Prepare two improvised beaker one with water label it **A** and one with too much salt solution and label it **B;**
5. Weigh the mass of each egg using an electronic scale and record the mass in table;
6. Place egg **A** in water (hypotonic solution) and **B** in salt solution (Hypertonic solution)
7. Weigh the egg on 15 minutes interval for 45 minutes;
8. Calculate the percentages change in mass, show your work and record the % on the table;
9. After an experiment; place the eggs in clear containers, observe and feel the texture of the egg;
10. Draw the conclusion of the experiment.

WORKSHEET: Demonstration of osmosis using the egg

Group:…… **Date**……

1. Record to complete the table (2)

	Egg A		Egg B	
	Mass	% change in mass	mass	% change in mass
Initial mass				
after 15 minutes				
after 30 minutes				
After 45 minutes				

(4)

2. Calculate percentage change in mass, show your work

3. Observe and feel the texture of the egg after experiment and write down your observations. (4)

4. Using the evidence from the experiment results, what conclusion can you make, Give your reasons (3)

…

Appendix 19: Reflections on model lesson development (Workshop 3)

Teachers were asked to reflect on their experience in developing the model lessons about mediation of learning osmosis using easily accessible resources. There some guiding questions were given so that teachers can able to reflect. This means, teachers were asked to reflect on their experience in developing the model lessons on teaching osmosis using easily accessible resources. Both three teachers indicated that, it was challenging to develop lessons. However, they differed on how they perceived the challenge. **T1** said, "developing the model lesson plan of osmosis was very challenging since some materials were hard to find". On the same note, **T2** indicated that "I experienced some challenges and I learned to be ready or prepared for them in future". T 2 continued that, I had a challenge of materials not available so in future a learned to be well prepared and have some extra materials just in case".

In the process teachers were asked to share their strengths when they were developing the model lessons. Teachers they reflected as follows:

T1 also shared the strengths to enable to develop model lessons, that working as a team or group was the most interesting thing; I gave me opportunity to see what I should include in the lesson.
The other good thing was that learners were involved and were asked to bring some of the materials from homes that were used during the lesson.

T2 indicated that would have confidence and indicated because lessons were well prepared. I use local materials to present the lesson which are funny to the learners which include learning

T3: I was confident in developing the model lessons because learners had the background knowledge or the prior knowledge on osmosis in plants (potatoes). I had no doubt on what I taught because I was well prepared and my lesson was planned.

.
Teachers shared the challenges in developing the model lessons as follow:

T1: I had a fear that some materials may not be obtained or may not work well. Time was also short to prepare the lessons, and the text books does not have enough information.

T2: materials were difficult to find therefore improvising was the option. "It was a bit challenging to find out which materials can be used to introduce the topic osmosis to open their minds" (2).

T3: " during the listing of materials need for model lesson discovered that some materials were not available eventhough I improvise beakers, were not enough so we used bottle containers"

Teachers also shared how the exposure to easily accessible resources impacted their experience and knowledge they had about osmosis as follow:

T1: I know understand, I can plan any lesson well, especially to set up procedures for the activities. it was nice experience.

T2: This model lesson impacted me in the positive way since, I observe osmosis in reality. I learned that osmosis is a process that took place almost in our daily activities. Example,, in dry fruits and preserving food. After experiment I found that out that osmosis even took place when cooking or washing. This had opened up my mind about osmosis, I understand very well to the experiments using local materials

T3: After the usage of easily accessible resources I believed that most if not all practicals can be performed at schools like ours with no materials due to fact that I can always improvise by using the local available materials. Meaning, that unavailability of prescribed materials should not be the reason for not doing practicals in schools.

After sharing how their knowledge was shifted due to the exposure to easily accessible resources, teachers indicated that in future, if the same exercise is to be carried out in future; there are some of the things that they would do as follow:

T1: Plan well in advance, and prepare the materials that needed. I learn to use materials that available, and it save time too.

T2: I would borrow materials from nearby schools in order to avoid struggling with experiment.
I would use time wisely to finish my lesson on time. I could ask learners to bring local materials from home. I can search on internet more information about the experiment; increase my understanding which will benefit learners.

T3: Instead of using salt, I would use some solutes such as sugar and other solutes. I would use a different plant cell such as cucumber.

After the development of model lesson teachers went to present the lessons in their own classrooms. In the processes I observed how they were teaching lessons.

Colour meanings:

Olive green 40% - creating conducive environment
Orange accent 6, 40% - interactions
Dark yellow – dispositions
Red- challenges
Orange accent 6, 25% - Prior Knowledge
Enablers to develop resources
Purple: reflections

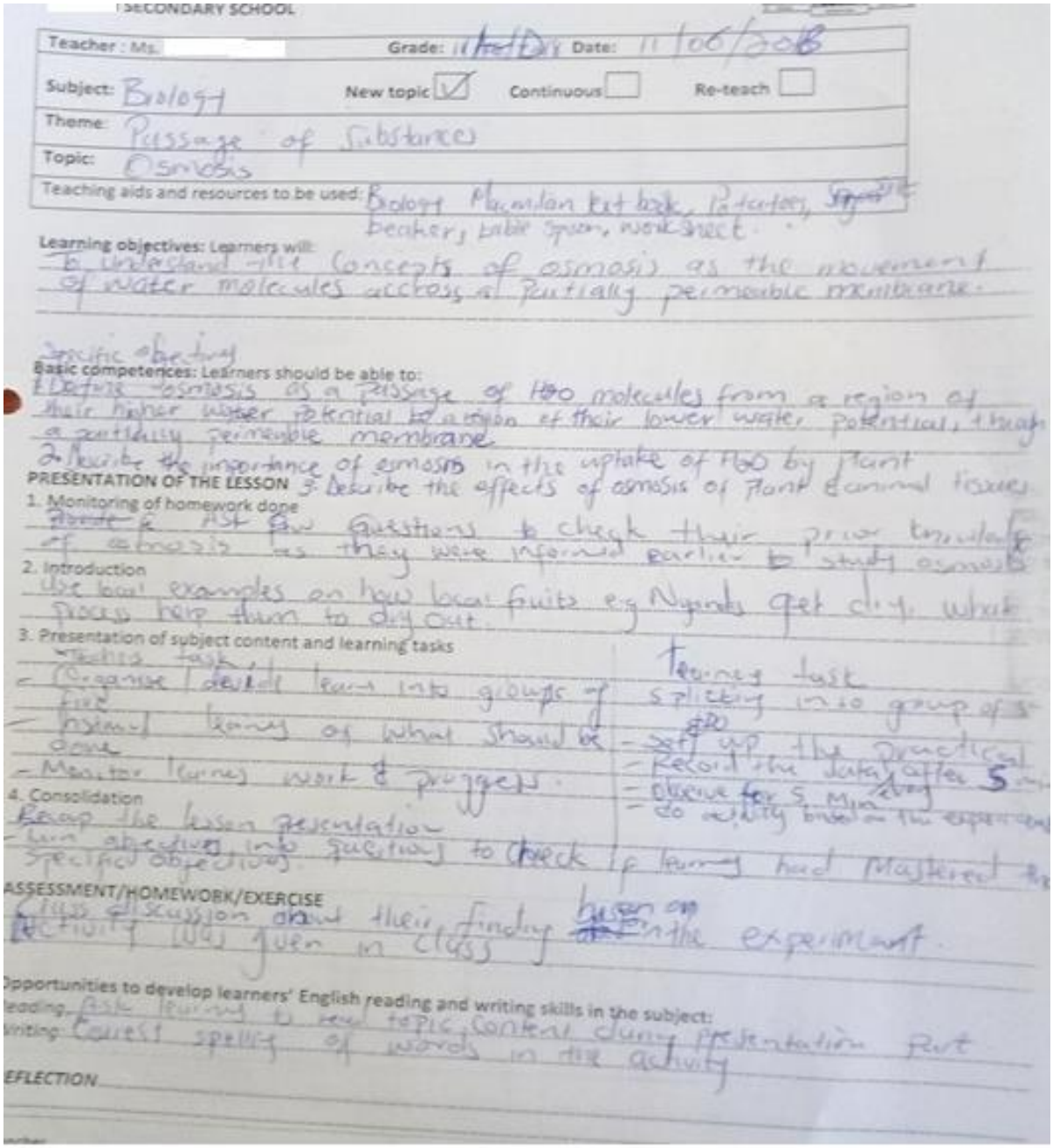
Formation of categories

Codes	Sub-categories	Categories
	After greeting the participants, the aim and objectives of the workshop 3 was shared with the participants:	Greeting the participants
	Aim of the workshop 3 was: • to share experiences on how best we use resources to develop lessons • to share how best we can use the resources in our surrounding to teach some of the complicated concepts such as osmosis. • discuss and co-plan and develop model lessons. Step 4: the development of the model lessons started and was done as a collective task, where all the participants took part. In the process teachers were asked to share their strengths when they were developing the model lessons Teachers were asked to reflect on their experience in developing the model lessons about mediation of learning osmosis using easily accessible resources **Presentation:** Learners and teachers' activities listed (Sample of lesson was used)	Interactions during the activity of developing model lessons Share how best to co-plan and co-develop for the lesson Share reflections Working together Teacher and learners activities
	The use of indigenous fruits were related to the food preservation which including drying/ storage The reason was for the learners to make sense of their environments, and the resources around them. Extract as part of discussion on the prior knowledge Although teachers wanted to continue with othe examples, they returned to indigenous practices; as shown in the extract that follow	Use of prior and indigenous practices, fruits, vegetables Make sense of immediate environment
	I can plan any lesson well, especially to set up procedures for the activities. it was nice experience (T1). This model lesson impacted me in the positive way since, I observe osmosis in reality (T2) This had opened up my mind about osmosis, I understand very well experiments using local materials (T3)	I can plan lessons well (T1 Positively impacted (T2) Open-up my mind (3) School with no resources can use easily accessible resources

	Resources I believed that most if not all practicals can be performed at schools like ours with no materials due to fact that I can always improvise by using the local available materials (T3) unavailability of prescribed materials should not be the reason fo doing practicals in schools (T3). **T3**: Instead of using salt, I would use some solutes such as sugar and solutes. I would use a different plant cell such as cucumber.	
	used the syllabus to analyse the specific information. The two extracts were used to guide participants during the develop of the lessons, by analysing what is expected to be achieved b learners in the activities. The first part of the extract was used to enlighten the participants curriculum expectations that prepare the learners to achieve the lea goals. The second part of the extract was used to identify the learning that learners should master i.e. learning objective and specific objec the lessons plans format was prepared to guide how much to be co during the presentations. The following document were also used to with regarding the lessons presentations The lesson planning was co-planned by the teachers, using the format which was adapted from the MoE, Subject Policy The lesson plan had the following components: • Teacher would introduce the lesson based on the previous lessons • A teacher to introduce the lesson that pre-tests the learners' prior knowledge Use following indigenous fruits to arouse learners' **prior knowledge.** Sources: Learners would source the lesson with various fruits (requested well in advance) on voluntarily basis. Extract as part of discussion on the prior knowledge Although teachers wanted to continue with othe examples, they returned to indigenous practices; as shown in the extract that follow Materials use for the lessons: the materials to be requested from learners well in advance prior to the lessons on voluntarily basis:	Use the syllabus to plan Highlight important points to be learnt Curriculum expectation Co-planning Guiding introduction (use prior knowledge and existing knowledge) Planning the lessons well in advance

	Sources: Learners would source the lesson with various fruits (requested well in advance) on voluntarily basis. Plan well in advance, and prepare the materials that needed I would borrow materials from nearby schools in order to avoid struggling with experiment. I would use time wisely to finish my lesson on time I could ask learners to bring local materials from home. I can sear internet more information about the experiment; increase understanding which will benefit learners.	
	Both three teachers indicated that, it was challenging to develop lessons. **T1** said, "developing the model lesson plan of osmosis was very challenging since some materials were hard to find". On the same note, **T2** indicated that "I experienced some challenges and I learned to be ready or prepared for them in future". T 2 continued that, I had a challenge of materials not available so in future a learned to be well prepared and have some extra materials just in case". **T1:** I had a fear that some materials may not be obtained or may not work well. Time was also short to prepare the lessons, and the text books does not have enough information **T2**: materials were difficult to find therefore improvising was the o "It was a bit challenging to find out which materials can be us introduce the topic osmosis to open their minds" (2). **T3:** " during the listing of materials need for model lesson discovere some materials were not available even though I improvise beakers, not enough so we used bottle containers	Developing the lessons not an easy activities Materials not easy to find Experiencing material=s default Not well prepared poses a challenge Not easy to improvise always

Appendix 20: Sample of model lesson plan



SECONDARY SCHOOL

Teacher : Ms. Grade: 11 Date: 11/06/2018

Subject: Biology New topic ☑ Continuous ☐ Re-teach ☐

Theme: Passage of Substances

Topic: Osmosis

Teaching aids and resources to be used: Biology Macmillan text book, Pictures, beaker, table spoon, work sheet.

Learning objectives: Learners will:
To understand the concepts of osmosis as the movement of water molecules across a partially permeable membrane.

Specific objectives

Basic competences: Learners should be able to:
1. Define osmosis as a passage of H_2O molecules from a region of their higher water potential to a region of their lower water potential, through a partially permeable membrane.
2. Describe the importance of osmosis in the uptake of H_2O by plant
3. Describe the effects of osmosis on plant & animal tissues

PRESENTATION OF THE LESSON

1. Monitoring of homework done
Revise & ask few questions to check their prior knowledge of osmosis as they were informed earlier to study osmosis
2. Introduction
Use local examples on how local fruits e.g Nyanks get dry. What process help them to dry out.
3. Presentation of subject content and learning tasks

Teaching task
- Organise / divide learners into groups of five
- Instruct learners on what should be done
- Monitor learners work & progress.

Learning task
Sticking into group of 5
- Set up the practical
- Record the data after 5 days
- Observe for 5 Min
- Do activity based on the experiment

4. Consolidation
Recap the lesson presentation
- Turn objectives into questions to check if learning had mastered the specified objectives.

ASSESSMENT/HOMEWORK/EXERCISE
Class discussion about their finding based on the experiment.
Activity [U4] given in class

Opportunities to develop learners' English reading and writing skills in the subject:
Reading: Ask learners to read topic content during presentation
Writing: Correct spelling of words in the activity

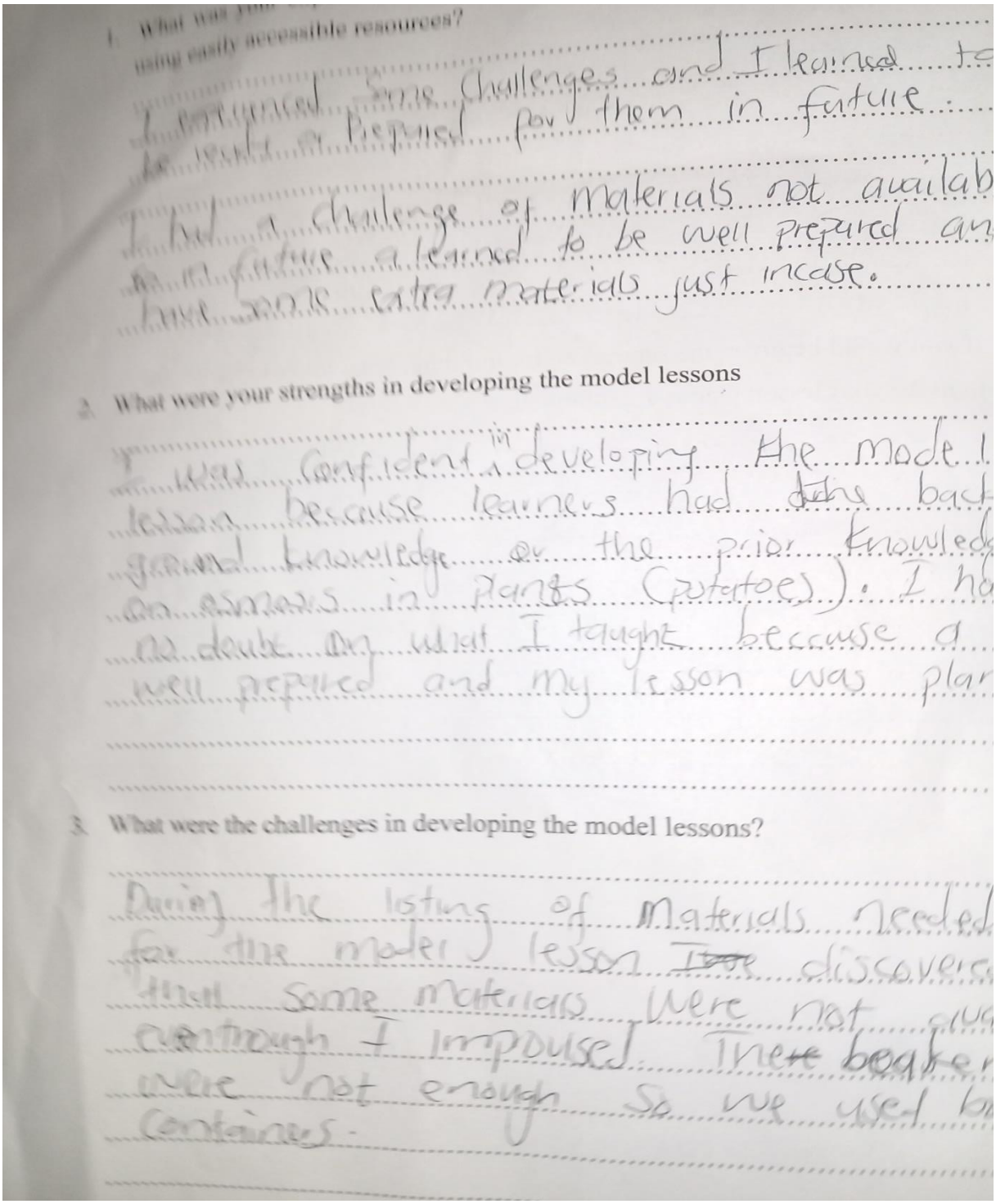
REFLECTION

Observation sheet for the teachers (cont…) Teacher 2

Observation sheet will help me determine how teachers mediate learning using easily accessible resources as per model lessons. *Adapted from Samuel (2017).*

Components	Activity	✓ Seen X not seen	comments
Lesson planning	As per model lessons	✓	was developed by all the partners
Materials	Easily accessible resources as co-planned and co-developed	✓	Included also Locally indigenous resources
introduction	Prior knowledge on the use of easily accessible resources	✓	Discussed and Mediated appropriately
Lesson content	• Demonstrating the role of mediator • Demonstration of the LCA (Learner-centered Approach)/ cooperative learning • Procedures followed as per model lessons co-planned • Manipulation on the use of easily accessible resources on practical activities. • Demonstration of the value of using easily accessible resources during mediation process • Social interaction (active engagement)	✓ ✓ ✓ ✓ ✓	During the classroom activities, teacher used all the materials needed as prepared from the teacher-made how he [illegible]. Learners were given a table and use the worksheet provided to do the activity, then lately discuss the findings.
Conclusion	Clear guidance on what to be done next	X	The lesson was not well concluded due to time limit

Appendix 21: Reflection on model lessons



1. What was your ... using easily accessible resources?

I encounted some challenges and I learned to be result of prepared for them in future.

I had a challenge of materials not availab in future a learned to be well prepared an have some extra materials just incase.

2. What were your strengths in developing the model lessons

I was confident in developing the model lesson because learners had the back ground knowledge on the prior knowled on osmosis in plants (potatoes). I ha no doubt on what I taught because a well prepared and my lesson was plan

3. What were the challenges in developing the model lessons?

During the listing of materials needed for the model lesson I discovers that some materials were not enough I improvised. There beaker were not enough so we used bo containers.

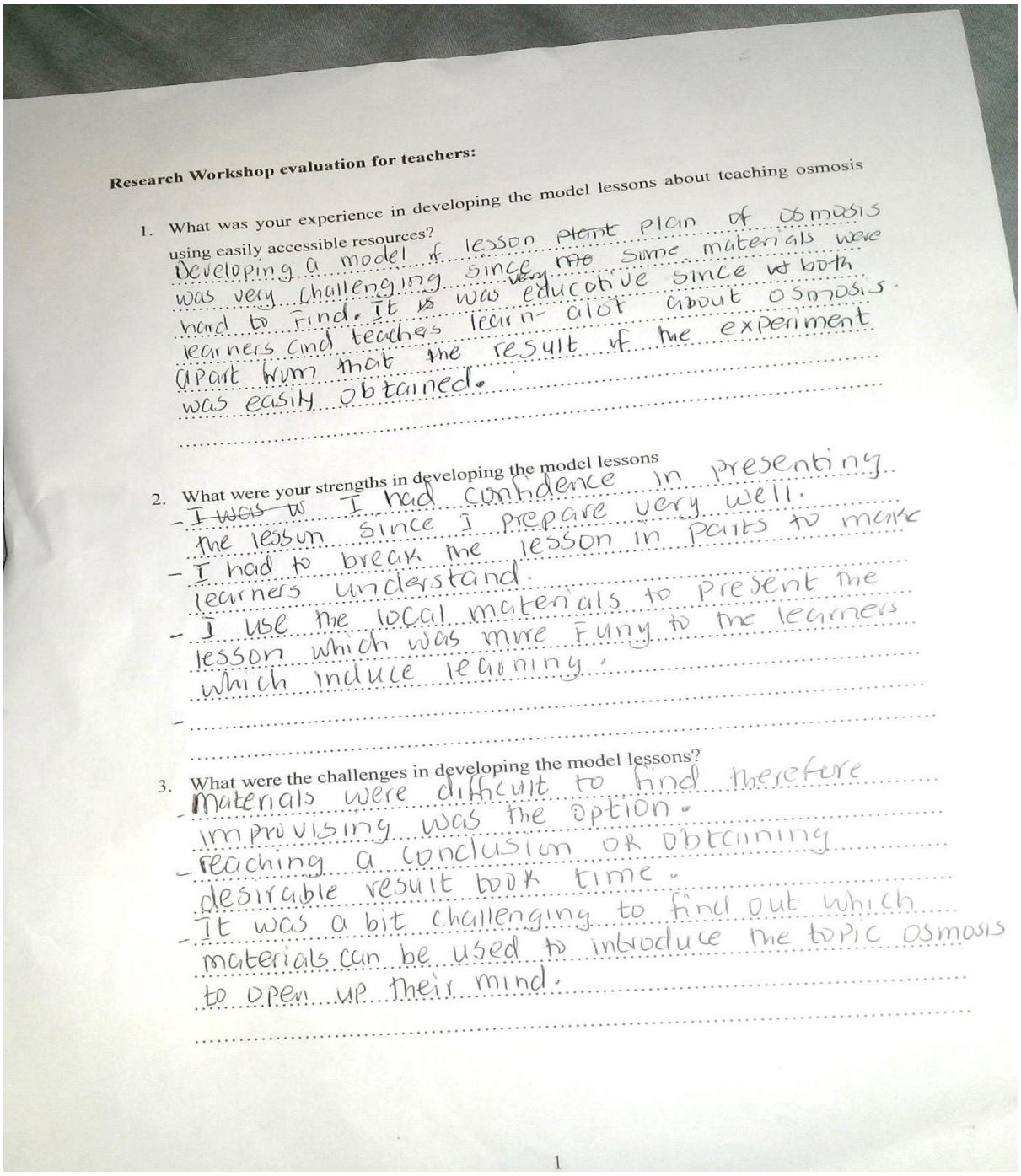
4. How such exposure does impacted your personal experience on teaching osmosis using easily accessible resources.

this made me to identify some local fruits like eenyandi that can be used instead of potatoes. After the usage of easily accessible resources I believed that most if not all practicals can be performed at schools like ours with no enough materials due to the fact that I can always improvise using the locally available materials. Meaning that the unavailability of prescribed materials should not be the reason for not doing practicals in school.

5. If you would be given the same exercise in future, what improvements will you make to make your lesson plan more informative?

- The experiment will be repeated.
- Instead of using salt, other solutes such as sugar will be used.
- A different plant cell will be used such as a cucumber or

Teacher 2



Research Workshop evaluation for teachers:

1. What was your experience in developing the model lessons about teaching osmosis using easily accessible resources?

Developing a model of lesson ~~plant~~ plan of osmosis was very challenging since ~~no~~ very some materials were hard to find. It was ~~wa~~ was educative since it both learners and teaches learn- alot about osmosis. Apart from that the result of the experiment was easily obtained.

2. What were your strengths in developing the model lessons

- ~~I was~~ I had confidence in presenting the lesson since I prepare very well.
- I had to break the lesson in parts to make learners understand.
- I use the local materials to present the lesson which was more Funy to the learners which induce learning.
-

3. What were the challenges in developing the model lessons?

- Materials were difficult to find therefore improvising was the option.
- Reaching a conclusion or obtaining desirable result took time.
- It was a bit challenging to find out which materials can be used to introduce the topic osmosis to open up their mind.

1

4. How such exposure does impacted your personal experience on teaching osmosis using easily accessible resources.

This a model lesson impacted me in the positive way since I observe osmosis in ~~ret~~ ret reality using materials that I am able to use. I learned that osmosis is a process that took place almost in our daily activity. example in dry fruit and perserving Food. After the experiement I found out osmosis even took place when cooking or washing. This had open up my mind about osmosis. I understand very well due to the experiment using local materials

5. If you would be given the same exercise in future, what improvements will you make to make your lesson plan more informative?

~~I would use materials fr~~

I would borrow materials from nearby school inorder not to strungle with experiement.

Time - I would use time wisely to finish my lesson on time. I could ask learners to bring ~~would~~ local materials e.g nuts, from home.

I can search on internet more information about this experiement, increase my understanding which will benefit learners.

,

Appendix 22: Classroom observations

Observation sheet for the teachers (cont…)

Observation sheet will help me determine how teachers mediate learning using easily accessible resources as per model lessons. *Adapted from Samuel (2017).*

Components	Activity	✓ Seen X not seen	comments
Lesson planning	As per model lessons		
Materials	Easily accessible resources as co-planned and co-developed		
introduction	Prior knowledge on the use of easily accessible resources		
Lesson content	• Demonstrating the role of mediator • Demonstration of the LCA (Learner-centered Approach)/ cooperative learning • Procedures followed as per model lessons co-planned • Manipulation on the use of easily accessible resources on practical activities. • Demonstration of the value of using easily accessible resources during mediation process • Social interaction (active engagement)		
Conclusion	Clear guidance on what to be done next		
Reflection	Evaluation on how the lesson was (to be discussed during the SRI).		

Appendix 23: Sample of stimulated interviews

Stimulated interviews (lesson 2) for Teacher 2

R: Afternoon Teacher 2, and how are you

T2: Afternoon mem, and how are you?

R: How do you feel me being in your class?

T2: I feel encouraged, because your presence made me to be strong, and do the right, although every time I do the right things, but when you are there, I feel honoured, and I feel encouraged.

T2: Thank you, aah: tell me more about, how do you find your lesson? Or how was your lesson?

T2: Aah. Aah., at the beginning I found it a bit more challenging because learners were not exposed to the reality of eee… the process of osmosis since our topic was about osmosis. But as the time go, then the lesson become more exciting, as now learners were able to… to... practice what learned there.

R: And, aah… why do you approach this topic the way. Remember you were referring to some of the indigenous practices or things that happening in the environments. You were giving examples of how they preserve food, and so on.

T2: Aaaaaa… I think it will give learners a picture about osmosis, and if a teacher is using practical examples were osmosis take place; in this way it enhance the learning process, and the learners will have a better understanding where do osmosis take place. Because sometimes they just learn theory but if we don't take them out of the class, then it will be difficult to get a clear picture of what we are talking about.

R: And the example of the washing of the hands that you gave, of when you are washing?

T2: Ooo, I used the example, that when you are washing the clothes and the concentration of the solution is too high. Let me say you are using salt water to wash your clothes; there might be certain things that you want to remove using the salts then it means water will moves from your cells into concentrated solution. And then your skin surface will look a bit like shrink or...

R: In your teaching you put more emphasis on the water potential, like the movement of water molecules from higher water potential instead of using the word concentration. Why you were much on that? Much time was spent on that?

T2: Yaa!! Some learners have wrong definition of osmosis from the junior grades and that wrong concept it sticks into their mind, and that need to erased. If they (learners) continue with that it will be difficult for them to understand that process of osmosis, because about osmosis we are talking about water molecules not any other solutes. So that learners can get a clear picture of osmosis and avoid confusion.

R: So they are confusing the two terms.

T2: Yes, if the learners omit the word water potential then, the definition of osmosis wrong, it is like defining diffusion. It is important to use the word water potential.

R: That's what do you think about the learners' responses about osmosis on daily life situations, what do you think, how does it contributed to what learners know.

T2: Aah..., aah. learners were bit stuck and finding it difficult to identify where osmosis take place in daily life but the moment that I gave them one example, it opened their minds, and think of different ways. And also, they were so aah... like amazed as they realized that aah… osmosis is the process that helps water to move.

R: That's quite interesting point eee…, and during experiment they were doing; you were moving around the table; do you think the learners are getting the results that are expected to make conclusion, as they were discussing? Are they really getting something from that or is there any group that was stuck?

T2: It was really exciting; as most of the learners were excited , finding the practical lesson more enjoyable, and found out exactly how the process of osmosis occur. When we were moving around the table; we found out that, the eggs that were put into different solutions, they end up having different mass. The eggs that were put into the hypertonic solution they end up aah… losing more water and their mass reduced. And the ones that put into the hypotonic their initial mass increased. I also found out that, learners now got a clear picture on the process of osmosis when they look at the change of mass for the eggs.

R: And now, that group that were not having beakers? They were having cut bottles (improvised bottles). Has that affected any expected results? Or did they get any desirable results:

T2: Yaa! they (learners) they got the desirable results, because what is important it is not about, eee… using the right materials (conventional); as longer as you are using any container. What matter is the amount of solutions that need to be the same, such as the right amount of water, the right amount of hypertonic or hypotonic. Then the results were just the same, as those used the beakers. So there was no effect simply that they were using the improvised materials. They just got their results as others.

R: This means that, the use of easily accessible resources were more useful?

T2: I think it is important for the teacher to think out of the box, that if you do not have the recommended materials; you can always improvise. What important is that; as long as you are following correct steps to carry out the practical activities.

R: That's very good! And as you were doing that practical activity; what could be done better to improve, even in the use of materials, and so on? Just anything that can be done to improve the lesson in future.

T2: Aaaaaa… aah. I think may be learners needed more time for the observations. Aaa ... in the case of the eggs; they can be put in the vinegar for three days so that the shell can dissolve nicely. Because, we found out that some eggs their shells were on, and we tried to remove it; as results some of the eggs enter up breaking.

R: So those are some of the challenges ee?

T2: Mhhhh! The other challenge is that, these practicals can be done in the room were windows are closed, because if done in the room where windows and the door open, it may move the eggs, and affect the mass of the eggs.

R: Alight, and mhhhh… about ... you mentioned that you have used the boiled water; what can you say about that; has this affected the results? What do you think?

T2: Yaa, it is better to use […] I don't think there is really a difference. There is no difference if learners using distilled water or boiled water. This is because, the results are almost the same ; but if the learner use water from the tap, it might contribute to not getting the correct results. This affect the movement of water; because that water (tap water) contain some chemicals which may affect the results. It is better to use distilled water or use boiled water.

R: Ok, that's good. Thank you so much. Do you have anything else would you like to share with me as far as this teaching osmosis is concerned?

T2: Aaaa… I think people need to be educated about this this process (osmosis), the effect of this process to animal cell and plant cells. And for us human beings, we need to know the effect of this process, when it comes to our cells. Thanks.

R: Thank you so much for all the contributions to this study.