Understanding how Grade 11 Biology teachers mediate learning of respiration: A Namibian case study

A thesis submitted in partial fulfilment of the requirements for the degree of

MASTER OF EDUCATION

(SCIENCE EDUCATION)

of

RHODES UNIVERSITY

by

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December 2014

DECLARATION

I, Laina N. Amutenya, hereby declare that the work presented in this document is my own original work and references to work done by other researchers have been dully acknowledged.

Signature--- Date-----------------------

ABSTRACT

The new curriculum in Namibia has introduced a new approach to teaching and learning requiring teachers to make use of learners' prior everyday knowledge (PEK) including indigenous knowledge (IK) and practical work/activities. It further emphasizes some variations in teaching methods such as; the use of analogies, the use of mind maps, and so forth with the aim to actively involve learners in the learning process and develop skills to solve global challenges. The emphasis is on understanding of knowledge, skills and the will to use them appropriately throughout their lives.

The main aim of this study was to understand and document how Biology teachers mediate learning of the topic respiration. Informed by an interpretive paradigm, a qualitative case study was conducted at two secondary schools in the Kunene region. The participants were selected using a convenience sampling. Data were gathered using three main sources, namely, documents, semi-structured interview questions which culminated into a questionnaire and observations. Triangulation was thus used to give credibility, objectivity and validity to the interpretation of the data.

Data analysis in this case study involved a multi-stage process of organizing, coding and categorizing, synthesizing and summarizing. The audio recorded lessons were transcribed into text and I analyzed data using a colour coding technique by segmenting and labelling text to identify descriptions and broad themes in the data.

Vygotsky's Mediation of Learning and Social Constructivism in conjunction with Shulman's Pedagogical Content Knowledge (PCK) informed the data analysis process. Teacher-learner interactions were the main theme for mediation of learning (social constructivist perspective), hence during analysis I paid more attention to moments where interactions evolved and I used PCK to gain insights in teaching and instructional strategies used by teachers.

The findings of this study revealed that: 1) teachers endeavor to use a variety of teaching methods such as the use of a mind maps and question and answer method. Learners were keen to ask questions in order to understand this topic. 2) The study also revealed that a lack of practical activities is one of the challenges teachers are faced with. Based on my research findings, I therefore suggest that there is a need for continuous professional development of

biology teachers and capacity building in order to improve both their content and pedagogical content knowledge.

ACKNOWLEDGEMENTS

A number of people have contributed in various ways to the successful completion of this thesis and I would like to acknowledge their contributions.

Firstly, I am indebted to the Almighty father God who gave me strength, courage and made everything possible to complete my research successfully, Father you have been the pillar of my strength.

I would like to thank my supervisors: Dr. Kenneth Mlungisi Ngcoza and Dr. Charles Chikunda for their motivation and superb efforts to guide me throughout this research journey up to this stage. I extend my sincere appreciation to the participant teachers for availing their time, and who were able to accommodate my research in their busy schedule.

I am also indebted to my girls: Paulina and Irja for enduring my absence. Paulina and Irja, I thank you once again for your understanding. I do regret having being away from you during the struggle for this research. To my parents Lukas Nuuyoma Amutenya and Madam Laina Ndakola Amutenya who laid a solid foundation despite limited resources at their disposal, I thank you. I would also like to extend my appreciation to my cousin Ndapandula and my sister Nalimanguluke and the neighbours for taking care of my girls, ladies I salute you!

I would like to thank Mr. Haindongo Immanuel Haindongo, who was my immediate supervisor at the beginning of this research and also thanks to my grade 10 learners and entire community of Epoko Combined School for being considerate and permitted me to take study leave on part-time basis. I would also like to acknowledge my fellow Rhodes students for their lengthy discussions, sharing of ideas and travelling the bumpy road together to Okahandja and Grahamstown.

Many thanks to others who have been role players and sources of inspiration and whose names might not appear in this document, your contribution is valued and I thank you all.

DEDICATION

This research is dedicated to my children Paulina and Irja, my father Mr. Amutenya and his wife, Laina; my late brother Jacob Amutenya, and my late cousin Rebbeka Shikongo-Neshuku who passed on while I was attending the fifth session of my first year in Grahamstown, South Africa. I dedicate this thesis to you because you are the reason why I am who I am today. This thesis is also dedicated to the entire family and its generation as both an academic stepping stone and a mile stone in my career.

ACRONYMS, ABBREVIATIONS AND SYMBOLS

AIR-American Institute for Research

CO_2-Carbon dioxide

$C_6H_{12}O_6$-Glucose

DNEA-Directorate of National Examination and Assessment

EK-Everyday Knowledge

ESL-English as a Second Language

ELL-English Language Learning

EMIS-Education Management Information System

ETSIP-Education and Training Sector Improvement Plan

H_2O-Water

JSC-Junior Secondary Certificate

IEA-International Association for the Evaluation for Educational Achievement

IK-Indigenous Knowledge

LCE-Learner Centred Education

LO1T1-Lesson Observation 1 Teacher 1

LO2T1-Lesson Observation 2 Teacher 1

LO1T2-Lesson Observation 1Teacher 2

LO2T2-Lesson Observation 2 Teacher 2

LPlanT1-Lesson Plan Teacher 1

LPlanT2-Lesson Plan Teacher 2

MLE-Mediated Learning Experience

MKO-More Knowledgeable Others

MoE-Ministry of Education

MBEC-Ministry of Basic Education and Culture

NCES-National Centre for Education Statistics

NIED-National Institute of Education for Development

NNC-Namibian National Curriculum

NSATs-National Standardized Achievement Tests

NSSCO-Namibia Senior Secondary Certificate Ordinary level

O_2-Oxygen

PCK-Prior Content Knowledge

PEK-Prior Everyday Knowledge

PIRLS-Progress in International Reading Literacy Study

PISA-Program for International Student Assessment

RQR-Research Questionnaire Response

Q-T1-Quesionnaire Teacher 1

Q-T2-Questionnaire Teacher 2

S.A.-South Africa

SACMEQ-Southern and Eastern Africa Consortium for Monitoring Educational Quality

SMK-Subject Matter Knowledge

SRI-Stimulated Recall Interview

S1-School

S2-School 2

TESSA-Teacher Education in Sub-Sahara Africa

TIMSS-Trends for International Mathematics and Science Study

T1-Teacher 1

T2- Teacher 2

T1T2QRs-Teacher 1 Teacher 2 Questionnaire Responses

TLSM-Teaching and Learning Support Materials

ZPD-Zone of Proximal Development

UNESCO-United Nations Educational Scientific and Cultural Organisation

UNAM-University of Namibia

U.S.A- United State of America

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CHAPTER 1: SITUATING THE STUDY

Case study research is unique in that it leads to a different kind of knowledge compared to other kinds of research and it is more concrete. Case study knowledge resonates with the readers' experiences as it is rooted in the context of the study (Gay, Mills & Airasian, 2009, p.426).

1.1 Introduction

This chapter introduces my study whose main goal was to understand how two Grade 11 Biology teachers mediated learning of respiration. The particular research goal and questions are presented and the theoretical framework informing the study is sketched out. The potential value of the study is provided and key concepts stated. Finally, the thesis outline is provided followed by some concluding remarks.

1.2 Background to the study

The ensuing sections discuss the background to the study with reference to international, regional and local contexts. Literature on the performance of learners in Science, Mathematics and Language in several countries has been reviewed as a basis for improving teaching and learning in Namibia. The local context of this case study research is based on the Namibian curriculum policy.

The study is partly motivated by my own eight years of experience in the teaching profession of which six years were teaching Biology. As a professional teacher, I observed Grade 12 school leavers obtaining low marks which prevented many from entry to the Universities. These low marks in final examinations were due to learners' inability to express their ideas properly on examination papers (Nakale, 2012) and this evidence is corroborated by Examiners' reports (see Section 1.2.2).

1.2.1 The international and regional contexts

The National Centre for Education Statistics' (NCES) (1996) findings in Trends in International Mathematics and Science Study (TIMSS) can be used to examine our education system, scrutinize improvement plans and evaluate proposed standards and curricula.

The TIMSS tests are conducted every four years to Grades 4 and 8 since firstly implemented in 1995. According to Gonzales, Guzman, Partelow, Pahlke, Jocelyn, Katsberg and Williams (2004), the findings from TIMSS survey, depicted a general decline in science achievement scores from 1995 to 2003. South Africa and Botswana were the only countries in the Southern African Developed Countries (SADC) that participated in these tests at eighth grade level in 2003, 2007 and 2011. In countries such as Botswana, South Africa, Honduras and Yemen the tests for Grades 4 were given to grades 5 and 6 while the tests for grade 8 were given to higher Grade 9 because they were considered too difficult for the grades initially intended.

The TIMSS revealed that countries and learners are facing problems in scientific reasoning and knowledge application. Provasnik, Katsberg, Ferraro, Lemanski, Roey and Jenkins (2012) found from the TIMSS 2014 results that students performed much better in questions which required factual recall. This international assessment study provides clear evidence that can be used to improve teaching and learning of Mathematics and Science including Biology which is the focus of this study. The International Association for the Evaluation for Educational Achievement (IEA) accentuates that TIMSS reports are very powerful and helpful to teachers, educational administrators, policy makers and other stakeholders, as they provide insights into the function of an education system that can be used to reform and improve its practice in a particular country or worldwide. The findings above indicate that Namibian learners are faced with difficulties in learning science specifically in areas where reasoning ability is required.

The Progress in International Reading Literacy Study (PIRLS) assessed fourth grade learners' reading comprehension skills (Yamamoto & Kulick, 2007). Four countries including South Africa (S.A.) participated in Pre-PIRLS in which fourth grade learners were assessed in 11 languages while PIRLS was conducted at Grade 5 level in both English and Afrikaans. Both studies reported the importance of reading literacy in the language of learning and medium of instruction, whereby learners understand the meaning of concepts.

The PIRLS 2011 survey reported that countries that took part in the sixth grade assessment and countries who participated in Pre-PIRLS showed below average achievement. The PIRLS reports indicated high reading achievement among learners who were actively involved in their learning and reading in a conducive environment. This suggests that teaching pedagogies should adapt and consider how best learners can learn and teach them that way. It should be noted, as well, that NCES, TIMSS, Pre-PIRLS and PIRLS are mirrors through which we can see our own education system from an international perspective.

The open educational resources for Teacher Education in sub-Saharan Africa (TESSA), 2012 for Secondary school, highlighted the importance of making science relevant to learners' everyday lives, giving examples of the teaching of respiration. TESSA stated that by making science relevant to learners, students can be kept interested in science and see how science can help them to understand the world (ibid).

The Program for International Student Assessment (PISA) 2012 summarized the selected findings on the Mathematics, Reading and Science performance in the USA and other parts of the world. The PISA study indicated that the USA's average scores were lower than in the states of Massachusetts and Connecticut but higher than in Florida. Shanghai-China average scores in Mathematics were higher than in Peru. PISA found that of the top performing students in science, 27% were from Shanghai-China and 23% from Singapore. The highest average scores in science were obtained by learners from Shanghai-China followed by Peru. PISA found that U.S.A had lower average scores in all the three subjects assessed.

It was noted that language could be a stumbling block when learners are not proficient enough in grasping broad concepts in science (PIRLS, 2011). The TIMSS, PIRLS and PISA reports alluded to in this section, resonate with the Examiners' reports in the Namibia Senior Secondary Certificates (NSSC) and Junior Secondary Certificate (JSC) in Namibia. The Examiners' reports highlighted learners' Biological content knowledge as revealing a lack of reasoning skills and inabilities to apply their knowledge to given situations. This is both an international and a national concern, and teachers worldwide, from which Namibia is not exempted; need to find ways to tackle it. The reports presented that schools and teachers are fully responsible to nurture and damage learners' attitude toward science depending on the teaching pedagogies used.

Namibia developed and implemented the National Standardized Achievement Tests (NSATs) as recommended by the World Bank in an attempt to validate the data obtained from the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) studies. SACMEQ projects I, II, III are supported by the United Nations Educational Scientific and

Cultural Organization (UNESCO). These projects focus on reading, Mathematics and Life Skills tests for learners (Ferdous, 2013). These tests are administered to the sixth grade level.

The SACMEQ project was established in 1995, and now it is popular in many countries including, Botswana, Kenya, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, and Tanzania. The purpose of SACMEQ is to inform stakeholders involved in decision making by informing their planning for improved quality education. A number of research projects have been conducted around the world in relation to improvement of quality science education and Namibia agreed to develop a standardized test. The SACMEQ III of 2010 indicated that Namibia had improved learners' reading skills and Mathematics. There was an average improvement in reading, mathematics and science in Namibia although some regions including Kunene performed below average (Education Management Information System (EMIS), 2011).

According to Ferdous (2013), NSATs are tests that provide diagnostic information about what learners in grades 5 and 7 know and able to do in key learning competencies in the curriculum. The NSATs technical support is mainly from the American Institutes for Research (AIR) through the Directorate of National Examinations and Assessment (DNEA) (ibid). NSATs are components of a larger Education and Training Sector Improvement Plan (ETSIP) for improving learning achievement in both primary and secondary schools through helping to monitor school progress.

In his Namibian study, Shaakumeni (2012) noted that NSATs were introduced in Namibia to provide diagnostic reports for both teachers and learners. NSATs provide information on how learners are achieving in relation to national and regional levels and at the same time diagnose difficulties (ibid). He explained that at school level, teachers could use the diagnostic reports to assist learners with the problems they were experiencing with mastering the key skills and competencies specified by the Namibian syllabi (ibid). Complementary to the above, the NSATs results would assist in identifying areas where professional support for teachers would be needed to improve learners' performance (Ferdous, 2013). Since quality education is a national concern especially in science, various efforts have been made to find solutions to particular problems in different subject areas including that of respiration in Secondary School Biology.

Many researchers in various parts of the world have indicated that the topic cellular respiration, while relevant to learners' everyday life, was considered to be difficult for learners (Kinchin, 2000; Cakir, Geban & Yuruk, 2002; Al Khawaldeh & Al Olaimat, 2010; Nakale, 2012) (see Section 2.2.3). Similary, Cakir, et al. (2002) identified some of the misconceptions experienced by Biology learners due to lack of understanding of respiration concepts.

The study by Cakir, et al. (2002) in Ankara revealed that learners found it difficult to understand cellular respiration due to the language needed to explain concepts which could easily be misunderstood by students. They argued that the pedagogical knowledge used to explain concepts was not familiar to the context of the learners and attempts to simplify the concepts often led to misunderstanding.

Agreeing with this, Allen and Tanner (2005) discussed strategies to develop students' deeper understandings of concepts on respiration within a scientific discipline. They agreed to the notion that students come to the subject of Biology in high school with significant prior knowledge. Therefore, they proposed that the notion of "*tabula rasa*" (ibid, p. 112) should never be over-emphasized. Yet, teachers often invest little time to find out what learners already know, what they do not know, what they understand, what they are confused about and what their conceptions about new knowledge intended to learning are (ibid). The experiences that learners bring to Biology classrooms should not be ignored. Otherwise, that will limit their way of thinking and they may not see the connection between the world outside school and what is taught and learnt in school.

Similarly, in their study conducted in the United Kingdom, Pine, Messer and John (2001) postulated that children do not come to science classrooms with empty minds but come with rich knowledge about their physical world based on their everyday experiences. They asserted that it is teachers' responsibility to organize children's naïve ideas into coherent reconceptualization which are both accurate and explicit. Lending support, Kasanda, Lubben, Gaoseb, Kandjeo-Marenga, Kapenda and Campbell (2005) suggested that before introducing learners to new concepts, more consideration should be given to contextualizing science by making use of locally available materials and existing local knowledge.

Based on his study conducted in Namibia, Nakale (2012) reasoned that poor performance in Biology may be caused by a number of factors such as English language use and the use of unfamiliar biological terminologies. These issues had been raised in the Examiners' reports of previous years as far back as 2008 up to date. For instance, Examiners' reports for the year 2013 repeat the same comments on learners' performance in Biology at grade 12 end of year examination. However, it is recognised that these problems are not unique to Namibia as illustrated above.

In the same vein, Homateni (2012) in her study conducted in Namibia shared some insights on how learners can best learn. Together with learners, she explored prior everyday experiences that learners brought to science classroom. Her study revealed that learners' level of engagement depended on how their everyday experiences were catered for in science lessons, using a variety of teaching methods. She found that learners could comfortably relate what they were learning in schools to what they were experiencing outside, if these two kinds of knowledge were brought together in the science classroom.

Uushona's (2012) Namibian study resonated well with Homateni's (2012) findings. He researched fermentation process in respiration using indigenous practices. He found that learners were able to visualize the link between school science and home science. Learners were also able to make sense of the process as they were involved in observations. Consequently, observations and explanations given by a community expert helped learners to grasp the concepts of fermentation and the importance of indigenous knowledge particularly that one of '*Ombike*', a traditional brew usually made from natural available fruits.

1.2.2 The Namibian curriculum and the motivation for this study

Soon after independence in 1990, education system reform was introduced in Namibia in an attempt to equalize access opportunities to education to all (Nyambe, 2008). This reform came with its new pedagogy of teaching known as learner-centred education (LCE) which was adopted in all Namibian government schools (Ministry of Basic Education and Culture (MBEC), 1993). LCE has drawn on various theories among others, the progressive education of Carl Rogers and John Dewey, Piagets' work in cognitive psychology and the social constructivism model of Vygotsky. Several researchers have indicated that the LCE approach has been also adopted in

African countries such as Nigeria, Zimbabwe, South Africa, as well as recently in Namibia (Kasanda, et al., 2005; Thompson, 2013).

The LCE approach requires teachers and learners to interact with each other and with the subject content so as to give learners opportunities to take responsibility of their own learning. As indicated in the MBEC (1993), LCE places learners at the centre of learning by considering their interests and active involvement. In addition, LCE recommends that teachers should take their learners' prior everyday knowledge into consideration during teaching and learning. Essentially, in LCE approaches, teaching methods such as group work are preferred over teacher talk. Similarly, the teacher is regarded as a facilitator of learning as opposed to the traditional method where a teacher is viewed as the only source of knowledge and transmitter of knowledge. In his study conducted in Namibia, Nyambe (2008) found that the LCE has not been successfully implemented due to teachers' interpretation and practice of the new approach in their classrooms. He highlighted some of the constraining factors, namely, lack of skills, limited and unequal distribution of resources and overcrowded classrooms. The resolution to this problem was seen as the move from traditional approach to LCE approaches as required by the Namibia Broad Curriculum of Education (2010).

LCE approaches are clearly defined and prescribed in the Biology Ordinary-level syllabus. Learners are required to study and be assessed on the concepts underlying respiration (Ministry of Education, National Institute of Educational Development (NIED), 2007). The topic is connected to other major themes such as photosynthesis, respiratory system and circulatory system. In addition, learners are expected to demonstrate certain competencies after studying respiration. Specifically, the syllabus states that learners should be able to:

- *define respiration;*
- *know that anaerobic respiration yields relatively small amounts of energy in the absence of oxygen;*
- *know that aerobic respiration yields relatively large amounts of energy in the presence of oxygen;*
- *define anaerobic and anaerobic respiration;-state the balanced equation for anaerobic respiration in muscles and yeast cells using words and symbols;*

- *describe the role of anaerobic respiration in brewing and bread-making; and*
- *describe the production of lactic acid in muscles during exercises.*

(Namibian Institute of Education Department (NIED), 2010, p. 27)

The Examiners' reports of the Ministry of Education in Namibia (2012) indicated that many learners experienced difficulties in topics such as the circulatory system, genetics, inheritance and respiration in particular, which is the focus of this study. It revealed that 28.6% of candidates did not know that yeast cells respire anaerobically to produce alcohol and carbon dioxide. Learners were also asked to define anaerobic respiration, but the majority confused anaerobic respiration with breathing rate (ibid). Examiners' general comments included: lack of proper reading of instructions, not spelling biological terminologies correctly and lack of understanding of action verbs in the syllabus, for example, describe, explain, and discuss (Nakale, 2012).

Thus, the Biology Namibian Senior Secondary Certificate Ordinary level (NSSCO) examiners' reports of the Ministry of Education (2009-2012) confirmed that most learners found a significant challenge with respiration concepts as their responses to questions were often inadequate and inaccurate. In some cases candidates were unable to answer questions considered by examiners to be straight forward. Their responses often lacked the scientific terminology needed to score marks. If any critical thinking was required in certain questions only a few top students gave correct answers (Ministry of Education Examination reports of NSSCO, 2008, 2009, 2010, 2011, 2012 and 2013). A review of the international literature shows that such problems of teaching and learning about respiration were not unique to Namibia but were also encountered elsewhere (Section 1.2.2).

From my personal experience as a learner, biology appeared to be an easy subject but in the externally examined end of year examination in grade 12 I was surprised and disappointed to obtain a C grade. When I became a Biology teacher I also found that students believed they understood many concepts but when tested it was often discovered that they did not. This raises questions about the effectiveness of some of our mediational tools (teaching strategies). In my six years of teaching biology, respiration is one of the topics that I have found students to have persistent difficulty in understanding.

The findings above and my own experiences as a student and a biology teacher aroused my curiosity to dig a little deeper into the nature of the problem and find possible solutions. This motivated me to conduct a qualitative case study to explore and gain insights into how two Grade 11 biology teachers of Kunene region mediate learning of respiration.

1.3 Potential value of my study

- This study can be of value in informing science teachers on better ways to introduce and teach respiration concepts. At the same time, through exposure to other teachers' practices during observations, reflection on their own practice might help them to improve their practice. Thus, this study may give insights to biology teachers into how to mediate learning and improve learners' conceptions in biology in this topic.
- A model practical activity lesson on respiration was developed in collaboration with the research participants. This teaching resource takes into account the challenges learners face in grasping respiration concepts. For that reason, the developed unit of work on respiration usefully supported me and other teachers during our mediation of respiration.
- I engaged with various studies internationally, nationally and locally but did not find any study in Namibia specifically on mediation of respiration; apart from evidence from that learners generally experience difficulties with the subject content (see Section 1.2.2). Therefore, this study may be used as reference for future research and give some direction on combating learners' problems with this topic.
- Curriculum developers may gain some understanding of issues around the mediation of respiration and may use this information when developing resource materials on this topic.

Thus, the study's findings may not only improve my own teaching practice on this topic. But it could also potentially provide others with some insights into how one might engage pedagogically with learners' prior everyday knowledge while at the same time teaching modern scientific explanations in a learner centred approach.

1.4. Research goal and questions

Research goal

The main goal of this study was to understand how Grade 11 Biology teachers mediate learning of respiration.

Main research question

How do Grade 11 Biology teachers mediate learning of respiration?

Sub-questions

1. What are Grade 11 Biology teachers' views and experiences of mediating learning of respiration during their lessons?
2. In what ways do Grade 11 Biology teachers scaffold learners to make sense of the concepts associated with respiration?
3. What challenges do Grade 11 Biology teachers experience in mediating learning of respiration?
4. In what ways can Grade 11 Biology teachers be supported with their mediation of learning of respiration?

1.5 Theoretical frameworks

The theoretical framework informing this study is drawn from Vygotsky's (1978) Mediation of Learning and Social Constructivism blended with Shulman's (1987) Pedagogical Content Knowledge (PCK). These theories are crucial to the teaching and learning in learner-centred education (LCE) as required by the Namibian curriculum. The Namibian curriculum requires pedagogical content knowledge of teachers to be framed within the LCE approach. In the context of this study, the LCE approach will help teachers to carry out their duties of teaching and learning through facilitating the understanding of the concepts of respiration.

1.6 Data generation techniques

Several data gathering techniques were used to strengthen the validity and trustworthiness of data in this study, namely,

- Document analysis;
- Observation;
- Interviews (which culminated into a form of a questionnaire); and
- Stimulated recall interviews.

1.7 Definition of concepts

It is necessary to define some key concepts that are repeatedly used in this study. These are respiration; teaching strategies, mediational tools, mediation of learning, zone of proximal development, pedagogical content knowledge, practical activity, prior everyday knowledge, scaffolding, and social constructivism (see Section 2.4).

1.7.1 Respiration: is the biological process in which energy is released from the breakdown of food substances in all living cells either in the presence or absence of oxygen (Chauke, 2011).

1.7.2 Teaching strategies: the methods that a teacher uses to help learners to master concepts within an organized set up (Vygotsky, 1978).

1.7.3 Mediational tools: the means through which mediation of learning is achieved, can be physical or psychological (Vygotsky, 1978).

1.7.4 Mediation of learning: is a process in which teachers interact with the learners in order to scaffold their intellectual development.

1.7.5 Zone of Proximal Development (ZPD): the distance between a child's problem solving ability when working alone and with the assistance of a more progressive partner (Vygotsky, 1978).

1.7.6 Pedagogical Content Knowledge (PCK) is the teachers' knowledge developed through an integrated process rooted in classroom practice, which includes knowledge representation of subject matter and understanding of specific learning difficulties and student conceptions (Shulman, 1987).

1.7.7 Practical activity: refers to a teaching and learning activity in which learners interact with a learning/teaching object using their various senses. Learners are allowed to manipulate and handle objects and have opportunity to make links between theory and the real world, (discussed in Section 2.3.4).

1.7.8 Prior everyday knowledge is the knowledge that learners bring to classrooms, acquired through their everyday experience and which can be scientific or non-scientific (Homateni, 2012) (see Section 2.3.2).

1.7.9 Scaffolding is the assistance given to learners during the teaching and learning process intended to support them to make sense of ideas (discussed in Section 2.4.1).

1.7.10 Social constructivism is a theory maintaining that knowledge is acquired through interactions in a social context (Section 2.5).

1.8 Thesis outline

The research study was conducted with two experienced teachers in government schools in Kunene region. The thesis consists of six chapters.

Chapter 1 has introduced and described the context of the study internationally, nationally and locally; and provided the reasons for undertaking the study. In this chapter, the research goal and research questions have been specified. A potential value of the study was provided followed by a brief discussion of its theoretical framework. The chapter also identified and defined key concepts frequently used. Finally, some concluding remarks are provided.

Chapter 2 reviews the literature relevant to my study. The literature reviewed is divided into subsections to clarify various aspects that may inhibit or enable the promotion of conceptual understanding of concepts associated with respiration in biology. Additionally, in this chapter I discuss the theoretical framework guiding the study.

Chapter 3 accounts for the qualitative methodological research selectively used for this study. The data gathering techniques and the rationale behind their utilization are narrated. This chapter also clarifies the qualitative research methods used to generate answers to the specified research questions in an attempt to achieve the main research goal. Reasons are explained for the use of a variety of data gathering techniques, namely, document analysis; and lesson observations. The use of purposive sampling techniques is discussed. The data analysis is outlined and ethical issues are discussed.

Chapter 4 presents the qualitative data gathered through document analysis, interview questions as well as lesson observations. The presentation of the data reflects the participants' own perspectives, thus, extensive extracts are used as references to keep participants' views. The questions asked in the questionnaire are turned into analytical statements, and responses summarized.

Chapter 5 is an analysis and interpretation of data infused with the literature reviewed in Chapter 2. The data is sorted and analyzed by coding and categorizing information from the emerging themes. The analyzed statements obtained from the data are discussed and integrated with literature. I pay particular attention to themes central to my research. Interpretations were done in line with the insights derived from the related literature around the topic.

Chapter 6 summarizes the research findings and offers some recommendations with regard to the mediation of learning of respiration. This chapter also brings forward the limitations of this case study, implications of the research findings, lessons learnt, recommendations and suggested areas for further future research. Finally, conclusions for the study are provided.

1.10 Concluding remarks on this chapter

In this chapter, the context and the reasons for undertaking the study, the theoretical frameworks, the research goal and research questions, definition of key concepts and the thesis outline were discussed. The next chapter is the review of literature around the mediation of respiration concepts.

Chapter 2: Literature Review

Children should not be taught creationism, which is irrational, but neither should they be taught that scientific investigation is our only tool of thought. Imagination can also bring us close to the unknowable powers of the universe, of which we are a part (Jennings, 2006, p. 15).

2.1 Introduction

This chapter begins by briefly introducing the expectations of the Namibian Curriculum of learning on the study topic of respiration. Several international and local studies on respiration are explored in order to present and illustrate various factors which might influence mediation of the topic.

The key respiration concepts that are covered by the Namibian Ordinal Level Biology syllabus are outlined. The chapter also explores misconceptions identified by researchers on cellular respiration and the challenges faced when mediating this topic At the same time, this chapter engages in literature which may be useful for biology teachers to explore in order to help their learners make better sense of biological concepts. The origin and account of the theory of mediation of learning is given as well as the mediational tools and methods used in teaching.

This chapter also reviews literature on the following conceptual framework and mediational tools used in this study, namely, relevance of prior knowledge of learners, use of practical activities and the role of language in science classrooms. Literature on the theoretical framework guiding this study, namely, Vygotsky's Mediation of Learning and Social Constructivism in conjunction with Shulman's Pedagogical Content Knowledge (PCK) are discussed followed by some concluding remarks. First I discuss the Namibian curriculum in relation to this research.

2.2 Namibian curriculum

The national subject policy for Natural Sciences aims to:

Strengthen the development of scientific literacy, understanding of scientific process through which learners will be able to apply scientific thinking and skills in real-life

> *situations. Learners should acquire understanding and knowledge through a learner-centred approach (p. 2).*

Despite this, neither the National subject policy guide for Natural Sciences nor the Biology syllabus (Namibia Ministry of Education, 2009) makes a direct reference to how science teachers should scaffold learners to make sense of concepts in cellular respiration.

In addition, the Namibia curriculum for Basic Education (Ministry of Education, 2010) advocates:

> *Teaching should start from what learners' already know and have experienced, and relate new knowledge to the reality around them, then, school learning can be meaningful. If teaching does not build on that experience so learning will limit the learners' thinking, and the learners will not see the connection between the world outside school and what is taught and learnt in school (p. 30).*

This advice could be achieved through incorporating various forms of mediation such as the use of appropriate biological concepts and learners' prior everyday knowledge as mean to identify learners' preconceptions and/or practical work in order for learners to express their ideas accurately.

The National Curriculum covers all subjects including science. The main ideas guiding science education specifically are indicated by the curriculum emphasis that teachers should provide:

> *…, through well designed studies of experimental and practical science, a worthwhile educational experience for all learners, whether or not they go on to study science beyond this level and, in particular, to enable them to acquire sufficient understanding and knowledge to become confident citizens (Namibia, Ministry of Education, 2010, p. 3).*

The curriculum for the Ministry of Education (2010) further asserts:

> *Learning in school must constantly relate to, involve, and extend the learners' prior knowledge and experience, and these must be complemented and challenged by the knowledge that school provides from beyond the immediate sphere of a learner" (p. 30).*

In the Namibian Ordinary Level Biology syllabus different key respiration concepts are outlined (Namibian Institute of Educational Development (NIED), 2010), namely, anaerobic respiration, aerobic respiration, writing and balancing of symbolic equations, the role of anaerobic respiration in brewing and bread-making. Despite a number of concepts outlined in the Namibian syllabus which are considered central to understanding respiration, some limitations have been discovered. As indicated in some literature (Kasanda, Lubben, Gaoseb, Kandjeo-Marenga, Kapenda and Campbell, 2005) and through analysing both the Broad Curriculum and the Namibian syllabus (2010), there are no clear guidelines on how teachers can scaffold learners apart from the outlined basic competencies.

As explained earlier in Chapter 1, both internationally and locally, the teaching of respiration has been found to be a challenging topic for learners and that might be attributed to teaching strategies and content knowledge of teachers (see Section 2.2.2). One would expect the syllabus to include some mediation guidelines of such topics. As accentuated by Cai and Ni (2011) in their investigation of the impact of the syllabi on mediation of learning in China, the syllabus is central to mediation of learning. The syllabus shows the content to be taught and consequently outlines how content mastery can be achieved (ibid). However, I did not find research carried out in Namibia on how respiration is mediated. This triggered my interest to investigate the issue.

In the upcoming paragraphs, I discuss the significance of learning about respiration, the challenges encountered during its mediation and some suggested possible solution.

2.2.1 Significance of learning about respiration at secondary level

The Namibian Secondary School Certificate Ordinary (NSSCO) level assumes that respiration is discussed at Junior Secondary Certificate Level from grades 8, 9 and 10 as indicated in this JSC syllabus (NIED, 2010). The basic definition or respiration and the expression of equations in both words and symbols are also introduced at JSC level.

The Teacher Education in Sub-Saharan Africa (TESSA, 2012) posits that all too often people see science as something only learnt from a textbook and not relevant to their everyday lives. It suggests an effective way to demonstrate the everyday reality of science is to start with the everyday context and use it to draw out scientific principles. The TESSA reports suggested activities such as baking cakes, growing vegetables, or mending a bicycle, all of which involve scientific principles. The document emphasises that the act of making connections between the things learners do at home and the science they learn at school can help to reinforce the scientific principles students need to learn.

Furthermore, TESSA (2012) reports that students can be interested and become engaged in learning if some controversies are involved; especially those related to real-life situations. For example, to demonstrate the relevancy of biology to learners, teachers need to relate it to their own bodies. When introducing a topic, teachers should refer learners to their participation in physical education and school sports (ibid). The TESSA reports (2012) also suggested that standard practical activity such as an enjoyable outside exercise can capture learners' attention and allow them to draw on their experiences as they discuss a biological topic in the class. This will help them to see how science can help them to understand the world. By such means, Grade 11 learners are expected to dig deeper into the relevancy and application of their knowledge into everyday life and so develop deeper conceptual understanding and develop higher order thinking skills (MoE, 2010).

As referred to the epigraph heading this chapter (Jennings, 2006), children's imaginations are also crucial in learning science. They should also be taught to think through using their experiences both in school and in the wider environment. The points rose above show how important it is for teachers to explore a variety of ways of scaffolding so as to effectively communicate biological concepts and the content knowledge. With that background we will try to understand how biology teachers mediate learning on respiration.

2.2.2 Knowledge base categories for teachers in mediation of learning

Besides the challenges associated with the nature of respiration and the scientific language needed for its understanding, some studies have also reported inadequate teachers' knowledge and skills as having a negative impact on effectiveness of mediation of topics. For instance, Nyambe (2008) indicated that teachers found it difficult to implement the reform curriculum due to inadequate knowledge on how to go about it. When teachers lack confidence on a topic, this may in turn cause misconceptions as discussed by Nakale (2012). In his study conducted in Namibia, he gave an example where one of his research participants explained to learners that *energy is produced*, which Nakale then had to rectify in relation to the law of energy conversion. In light of this argument, the limited subject matter knowledge of teachers negatively affects their pedagogical content knowledge which in turn complicates students' understanding of a topic such as respiration and its concepts.

The problems identified, however, might be eradicated or reduced by interventions to help teachers deal with the challenges they face in mediating this topic and these are discussed in the next subsection. In a small way and as part of this study, understanding the ways that biology teachers mediate learning in this topic would help to identify any area of support if a need should arise.

2.2.3 Challenges faced in relation to the mediation of learning on respiration

Despite the curriculum innovation concerned with the transformation of teachers' pedagogical practices, many Namibian teachers are still facing challenges to meet the curriculum demands. Internationally, numerous gaps and difficulties have been identified with respect to the teaching of this topic (Cakir, Geban & Yuruk, 2002; Allen & Tanner, 2005; Al Khawaldeh & Al Olaimat, 2010; & Nakale, 2012).

Correspondingly, a study conducted by Koba and Tweed (2009) in South Africa revealed that learning biology was generally a struggle for many learners as evidenced by biology achievement scores in many schools. These authors added that the struggle for learners to cope well with biology is due to very large content compounded by demands for more assessments and unachievable set standards with very short time frames to achieve the expected competencies. As a result, teachers tend to pay little or no attention to engaging learners in classroom discussions which might improve conceptual understanding and sense making of concepts presented to them. Since there is not sufficient time to engage learners in the learning process, experiments and inquiry based activities are often either ignored or not done properly.

A study conducted by Nyambe (2008) in Namibia revealed that inconsistencies in the use of scientific language, lack of connections between formal science and home science, overcrowded classrooms, lack of teaching resources can be also contributing factors of poor performance.

Lending support to Nyambe (2008), Mwetulundila (2009) pointed out that teaching science in schools in Namibia has been unequal, ranging from disparities of distribution of resources, lack of funding and teachers' poor proficiency in English. Overcrowding of classrooms made it difficult for teachers to extend the ways to teach and to reach every child so as to uncover misconceptions. The language of classroom communication made it hard for teachers to achieve the intended output. In addition, biology teachers found it difficult to teach in ways that best enabled their learners to reach set objectives. For instance, the curriculum recommends that teaching should start from what is known to unknown (Ministry of Education, 2010), however, learners' opinions and beliefs are rarely accounted for and usually not considered (Sunal, Wright & Bland, 2004).

The Language Policy for Schools in Namibia (Ministry of Education, 2003) emphasizes the need to know how to write and speak (p. 1). The language policy recognises the critical role of language in facilitating the acquisition of new knowledge and experience as proposed by Lemke (1990), who noted that the content of scientific and technical subjects can be expressed in language and that semantic resources of language are the foundation for all our efforts to communicate science as also other subjects. When language is used differently in class than in usual communication, making sense of a subject becomes much more difficult. Lemke (1990) argued that teaching science is teaching students how to *do* science and that can be guided and informed by talking science to ourselves and with others. Hence, he proposed the need to analyse how we use language so as to mean something.

In his Namibian study regarding language and science, Nakale (2012) contributed another dimension to these aspects. He identified how English, which is a second language in Namibia, is none the less an appropriate tool for communication in biology classrooms. He highlighted some criteria which were used to develop the language policy for all subjects from grades 1 to 12. One of the criteria is that English is an international means of communication in science, while language also transmits culture and cultural identity (ibid). However, Nakale (2012) noted that scientific language is one of the problems experienced by both teachers and learners in Namibia.

Furthermore, expression through the use of words should not be seen in isolation of other equally valid means of communicating ideas. Nakale (2012) remarked that flexibility was required of teachers and an ability to reflect on their teaching in their efforts to teach in ways that learners can best learn. These include practical activities, prior everyday knowledge and variety in teaching strategies.

2.2.4 Intervention to mediate learning on respiration

Several studies have suggested interventions to respond to challenges faced when teaching biology. However, I could not find any studies that explain how respiration in particular should be taught apart from TESSA (2012) reports and what the NSSCO level requires (NIED, 2010). I therefore relied on literature available from TESSA, NSATs, PIRLS, TIMSS, as well as examiners' reports to guide me on the status of this topic under investigation (see Section 1.2.1).

A study conducted in the USA by Allen and Tanner (2005) discussed strategies to develop learners' deeper understanding of concepts on respiration within a scientific discipline. These authors agreed to the notion that learners come to the subject of biology in high school with some significant prior knowledge. That should warn science teachers to be considerate to start with what learners already know before they introduce new concepts to them. That notion is in line of the Namibian curriculum of the Ministry of Education (2010).

Tekkaya (2012, p. 260) shared similar sentiments and suggested some teaching techniques that encourage meaningful learning, and conceptual understanding in biology, namely, concept maps, Venn diagrams, clinical interviews, portfolio and conceptual diagnostic tests. Teachers can explore the above strategies to see how best they can fit their situation. However, Tekkaya cautions teachers to take note that conceptual development can be promoted by classroom instruction that avoids excessive factual details, establishes meaningful connection between new and existing concepts and takes into account learners' prior knowledge (ibid, p. 261). In addition, simplified tasks and immediate feedback can yield better results.

In countries such as the USA there are many science centres that provide professional development and support for teachers on the incorporation of inquiry-based learning and real-life experiences (Rock, 2011). These centres help teachers to develop an understanding of science and discover flexible strategies to involve their learners in science learning. Inquiry-based teacher training helps to move them beyond a book based approach.

In Kahenge's (2013, p.19) study conducted in South Africa, she found that encouraging teachers' participation in professional development changes their teaching strategies as they acquire a deeper understanding of inquiry. She emphasised that "science centres can help teachers to improve their own understanding about science and discover new and flexible strategies that can effectively engage learners in science learning" (ibid, p. 19). Furthermore, Kahenge (2013, p.19) argued that effective instruction in any academic discipline should cultivate an interest in the subject and motivate learners to continue learning more about the subject.

2.3 What is cellular respiration?

Cell respiration is the release of energy whereby food substances are broken down in all living cells either in the presence or absence of oxygen (Ngepathimo, 2008). According to Ngepathimo (2008), there are two types of respiration: one that takes place in the presence of air called *aerobic respiration* and one that takes place in the absence of oxygen called *anaerobic respiration* (p. 73). Living organisms use energy released by respiration to carry out many different processes, to name a few:

- to move around, in order to look for food and hide from enemies;
- to obtain food and digest it; to speak in order to communicate with people;
- to reproduce in order to have offspring to maintain the human population; and
- to co-ordinate the body, grow and remove waste substances.

The term “cellular respiration” may seem to be a single and clearly defined biological or biochemical process, but in reality it refers to many different biochemical processes, with variation within and between types of organisms and biological circumstances (Wierdsman, 2012). A clear definition of cellular respiration is deemed crucial in this study and this is adopted from Wierdsman (2012), as a collection of metabolic pathways that release stored energy by breaking down complex molecules like glucose, into smaller and less complex ones. It can occur with the use of oxygen (aerobic respiration), but also without (anaerobic respiration or fermentation).

Different organisms can use different kinds of anaerobic respiration, e.g. alcoholic and lactic acid fermentation. Both processes consist of a series of enzyme-mediated chemical reactions which use glucose as exemplary fuel source (ibid). Campbell and Reece (2005) added another dimension to the definition of respiration as an anabolic metabolic pathway (which can be anaerobic or aerobic) that releases stored energy by breaking down complex molecules. He further explained that in aerobic respiration, oxygen is consumed as a reactant along with the organic fuel while fermentation (anaerobic respiration) is a partial degradation of sugars that occurs without the use of oxygen. According to Uushona (2012), anaerobic respiration is a process involving the breaking down/decomposition of organic materials (sugar/glucose) by microbes (yeast) to form alcohol (ethanol) and carbon dioxide gas in the absence of oxygen.

Furthermore he explained that, at industrial level, the process is used to make wines and beers using fruits. Some opt to add sugar as a catalyst to increase the productivity and speed up the reaction (ibid).

2.3.1 Misconceptions in cellular respiration

The 'unorthodox ideas' that children hold have been variously termed as preconceptions, alternative framework, alternative conceptions, naïve theories, naïve beliefs and misconceptions (Kinchin, 2000, p. 1). The term 'misconception' has been avoided by some authors as it is seen as judgemental (ibid, pp. 1-2). However, Kinchin (2000) criticised the above illustration and stated that, if we are unwilling to judge some ideas better than others then we give our students no incentive to change or develop their views, we give ourselves no incentives to design good curricula, or even to teach science at all (pp. 1-2), the term misconception will accordingly be adopted in this study.

In his research conducted in Namibia, Nakale (2012) raised some factors that may contribute to poor performance in Biology, such as English language use and the use of biological terminologies. For example, learners believe that '*respiration reaction produces energy'* which is technically wrong, because energy is never produced; it is only *released* (Law of Conservation of Energy) (ibid, p. 5). He further argued that some English second language speakers do not have the necessary tools to construct advanced scientific concepts, though even first language speakers experienced difficulties as well.

As a result, some of these learners encountered problems in understanding the instructions for activities, experiments and even some of the questions given in the examination papers, as indicated in the Examiners' reports (2012) as discussed in Section 1.2.

A study conducted in Ankara, Turkey by Cakir, Geban and Yuruk (2002, p.239) revealed that learners' views and explanations of science concepts may be incorrect and different from the ideas their teachers intended to convey. Learners' ideas are also often significantly different from ideas generally accepted by scientists. Furthermore, their study revealed some misconceptions in biology on topics among others: genetics; photosynthesis, digestive system and respiration which is the focus on my study.

According to Cakir, et al. (2002), some students believed that "glucose is the only substrate used in cellular respiration" (p. 239). They also found that students thought that "yeast releases O_2 in the fermentation process, and that O_2 is used during anaerobic respiration instead of CO_2; students believe that plants do not respire" (p. 241). Therefore, Cakir, et al. (2002) emphasized the need for instructional design that takes into account learners' primary conceptions seeing that meaningful learning requires accommodation of new ideas and reorganizing existing ideas.

Some other examples of misunderstanding of this concept recently identified by Al Khawaldeh and Al Olaimat (2010) in their study conducted in Mafraq, Jordan were:

> *CO_2 is used instead of O_2 in fermentation reactions; CO_2 is released during both aerobic and anaerobic respiration reactions; CO_2 is released during lactic acid and alcoholic acid fermentation reactions as end production; all living things utilize O_2 during respiration reactions; students defined respiration as inhaling O_2 and exhaling CO_2, (p.116).*

Another study conducted by Tekkaya (2012) in Turkey found that learner's misconceptions may be compounded by daily life experiences and the use of everyday language in scientific contexts, teaching strategies and textbooks. These findings have been confirmed by Lemke (1990). Such compounded misconceptions defeat the aim of the Biology syllabus which is to promote meaningful learning. Furthermore, Tekkaya (2012) explored some examples of students' preconceptions; students understood that living things are made of cells but did not extend their understanding to include the concept that those cells are made up of atoms and molecules as learned in physical science. Thus, he reasonably thought that the lack of prior knowledge in chemistry and physics contributes to misconceptions in biology as well.

Common misconceptions identified by Tekkaya (2012) on respiration are:

> *"The purpose of respiration is to provide oxygen and remove carbon dioxide; respiration is a synonymous with breathing; respiration takes place in lungs; respiration in plants occur only at night; some animals particularly invertebrates do not respire; animals respire aerobically while plants respire anaerobically; plants do not respire, they photosynthesis instead" (p. 262).*

Kinchin (2000) suggested that it may not only be the students' lack of prior knowledge that makes learning difficult as proposed by Roschelle (1995), but frequently a conflict between new knowledge and existing naïve theory. Kinchin (2000) further argued that terminologies are not only misleading because of changing patterns of usage, but problems also arise because of inconsistent usage dependent upon context.

2.3.2 Use of prior everyday knowledge as a mediational tool for learning

As indicated earlier in subsection 1.2.2, the Namibian curriculum requires learning to start from what the learners already know; that being an important point in constructivism theory (MoE, 2010). This is based on the understanding that learners do not come to science classroom with empty minds, rather they possess knowledge and information gained from either the previous classrooms or from the community. This prior knowledge whether correct or not, must be considered during teaching and learning.

This section examines prior knowledge both as a barrier to understanding and as a foundation on which to build new knowledge. In his Australian study, Roschelle (1995) described prior knowledge as a concept-base of perceptions and beliefs about knowledge in the science context. The well-established common sense beliefs about science that learners bring to school play a vital role in any scientific biological concepts to be learned. Roschelle (1995) explored the role of prior knowledge in learning science, and found that learners can make sense of given information if they could establish a link between home science and classroom science. Thus, Kibirige and Van Rooyen (2006) encouraged the incorporation of learners' prior everyday knowledge in science classrooms as it promotes a smooth cross over from known to unknown. This can also give learners' an opportunity to express their ideas and become actively involved in learning science and become contributors to scientific knowledge.

Roschelle (1995) confirmed that prior everyday experiences are the main source of learning rather than new material presented to the learners. This means that it can be critical to elicit prior knowledge and find ways to challenge it. He added that everyday knowledge is crucial for conceptual development and change. Indeed, as unorthodox ideas are refined over time and as prior knowledge is transformed, the new ways of knowing develop. Alternative conceptions can have impact on students' ability to learn every subject. Oloruntegbe and Ikpe (2011) argued that learners are more likely to achieve set standards and competencies when their experiences are considered. They claimed that learners' prior everyday knowledge can cater for deeper conceptual understanding during the mediation of learning. Thus, Sunal, Wright and Bland (2004, p. 2) suggested well-designed, hands-on activities as well as student-centred lessons.

Corresponding to that, Stears, Malcolm and Kowlas (2003) argued that a greater connectedness between school science and home science arouses learners' interests and leads to greater involvement which in turn yields good achievement. Teachers must design projects which enable schools to work with scientists in the 'real world', promote better student engagement and attentiveness in science (ibid). Kuhlane (2011) reasoned that everyday experiences must be included in teaching so that learners become interested, comfortable and are able to and understand science.

In the same vein, Allen and Tanner (2005, p. 113) alluded to the meaning of "understanding" as the ability of learners to explain, interpret, apply, account for reasoning and ability to identify limitations in their own understanding. Hence, in order to teach toward understanding concepts in respiration and achieve conceptual change in learners, teachers first need to understand learners' prior knowledge (ibid). It is also important to examine prior knowledge, identify confusions and then design teaching methods and instructions that can provide opportunities for existing and arrival ideas to collide, producing fascinating outputs.

Sunal, et al. (2004) confirmed the importance of learners' prior knowledge in determining what each individual can learn from a particular lesson in Biology. They asserted that individual learners assimilate and make sense of new ideas as advocated by the social constructivists such as Vygotsky (1978). Lemke (1990, p. 11) pointed out that educators should not assume that English Second Language (ESL) students already understand what a concept means if they have learned it in their first language. In that case more efforts are needed to identify learners' needs. This point is critical for teachers to sensitively select their approaches, and if properly identified and employed, it may generate further insights into learners' conceptions which can be used to develop a relevant intervention to support teachers and learners.

In contrast to the above benefits, Tyson, et al. (1999) critiqued that learners' prior everyday knowledge may inhibit understanding of new ideas or factual scientific concepts. For example, if teachers do not understand the impact of prior everyday knowledge in mediation of learning then difficulties may arise when incorporating prior everyday knowledge. Taylor (1999) expressed a similar concern and claimed that everyday knowledge is unstructured, wide and to an extent can be influenced by learners' environment. Therefore it can be awkward to consider individual experiences. Nevertheless, Taylor (1999) argued that incorporation of prior everyday knowledge during mediation demands organisation of ideas and it facilitates conceptual understanding. For example, photosynthesis should be presented as a reverse reaction to respiration so that learners become aware of the relationship between the two processes. In photosynthesis glucose is produced when green leaves combine water and carbon dioxide and during the process, oxygen is released.

Uushona (2013) suggested that teachers should spot key concepts regarding learners' everyday experiences and explore them with their learners. He explained that the investigation carried out in his own teaching practice enhanced meaning making and facilitated conceptual development in anaerobic respiration using indigenous knowledge. He found that the use of mind maps helped in concept development of fermentation in his lessons exploring 'Ombike', the traditional brewing. Uushona (2013) encouraged teachers to improvise in the absence of laboratory materials, highlighting the need for schools and communities to make joint efforts in teaching and learning of science.

2.3.3 Language as a mediational tool of learning science

Vygotsky (1978) saw language as the most essential psychological tool in the mediation of learning. He added that mental development takes place in two phases; social and psychological. Information is transmitted through social interactions, as between teachers and learners and among learners by means of language. The language is used to assimilate and align thinking skills in a logical way. Only through language can teachers help their learners to organise their ideas. Through language teachers can help their learners to acquire concepts intellectually by contextualising what they intend their learners to achieve.

Essentially, Lemke (1990) concurred with Vygotsky that language is central to mediation of learning. He explored how language is used in secondary schools to communicate and construct meanings in science. He commented that learning science, which includes biology, involves learning how to talk science meaningfully. He suggested that to talk science means learning to use specialised conceptual language for reasoning and problem solving, which many teachers find challenging. Lemke (1990) further commented that learners who study main courses in a foreign language often experience conflict between new and existing information. Since the concept definitions are written in English which is not often used outside the classroom, it takes serious cognitive processes and relentless support to unpack the definitions and make meaning out of them. For learners to develop appropriate conceptual meaning and understanding in cellular respiration, appropriate mediational strategies are further required.

Similarly, Hodson and Hodson (1998) considered language as a path through which meanings in subjects are passed on. Scientific language is different from other languages and hence considerable effort and time should be invested to teach the language of science (ibid). Inconveniently, learning science in a foreign language (English), limits understanding and mastering of scientific concepts of secondary school learners (Kocakulah, Ustunluoglu & Kocakulah, 2005).

Kocakulah, et al. (2005) conducted a study in Turkey on the effect of teaching in native and foreign language on students' conceptual understanding in a science course. They used a causal-comparative research design to determine the differences between students who took the science course in native and foreign language and the effect of language on conceptual understanding. They found that students who were taught a particular concept in a foreign language, namely English, had more misconceptions than those who were taught the same concept in their own mother tongue. Correspondingly, Brock-Utne (2001) argued that language is a big concern in learning science. The teacher's challenge (in the Namibian context as well) is therefore how to overcome misconceptions when mediating Biology content through English to second language speakers.

Though English is not the home language of either teachers or learners' in most Namibian schools, unfortunately it is a medium of instruction from Grades 5 to 12. According to a study conducted by the University of Namibia (UNAM) (2012), most Namibian Teachers' English proficiency is poor. This has prominent impact on the education of the learner, leading to poor academic achievement. In a study conducted in schools in Namibia, Nakale (2012) reported that teachers were unsure about how to teach English Second Language (ESL) students in mainstream classes due to the fact that learning academic content through ESL is quite a challenge. Nakale (2012) observed that learners' success in science depends both on the acquisition of English language skills and academic content in their context.

Although learners' cognitive development needs to be embraced throughout the learning process, Probyn (2004) proposed that code-switching from English to a vernacular language may help with cognitive reasoning in response to learners' limited English proficiency. She called this strategy 'smuggling vernacular' into classroom seeing that it conflicts with curriculum policy. The teachers' challenge as seen by Probyn (2009) is how to teach both the language and the content to learners. The knowledge and experience acquired in the home environment are not affirmed by the school, since the child is taught in a language that is not his/her home language. That causes the cognitive development of the child to be disrupted.

Probyn (2009) referred to code-switching as the use of two or more languages by bilingual speakers or language learners. Nilep (2006) indicated that code switching is a practice of selecting or altering linguistic elements so to contextualise talk in interaction. A person uses two language varieties interchangeably for broader contextual knowledge relevant to an ongoing conversation. Mastura, Azlan and Narasuman (2013) advised educators to view code-switching as a strategy to close the gap between languages that students are learning (p. 466), an essential instructional tool for language teaching and an interactional strategy for social interaction in science classrooms. Mastura, et al. (2013) noted that code-switching is normally used when a certain vocabulary is not available to a speaker in the first language or when emphasising a point to make the audience understand. However, Jalal (2010) criticised instructors who permit code-switching or code-switch themselves as not being exemplary to their students. He reasoned that second language learners require an amount of input and practice in the target language if they are to develop their fluency and competency in the targeted language of instruction.

One of the most influential studies in this area is that of Lemke (1990), who discussed some means of effective communication in teaching students to 'talk science'. He argued that miscommunication is most dangerous when we convince ourselves that we are communicating, but our partner in dialogue do not see it that way. He suggested that different kinds of dialogues, different styles, registers or context of social activity may be used to improve the communication. His study provided evidence and reasons for teachers to code switch when a common language is used to emphasise what teachers intend to communicate to learners.

To add weight to this, Hart (2003) argued that teachers' capacity development requires effective code-switching in mediating learning. Agreeing with this, Nyambe (2008) urged teachers to be mindful to develop sequence on how they can present topics and their concepts in their subjects. This is relevant in respiration, where for example, photosynthesis, respiration and pulse rate in the circulatory system, are all interwoven. Likewise, anaerobic respiration cannot be taught in isolation from aerobic respiration.

Nakale (2012) noted that learning biological concepts also means developing the capacity to communicate in the language of science and act as a member of the community of the people who does so. Such a community may be called a community of practice (Lave & Wenger, 1991). Nakale (2012) found that these issues, in the Namibian context, are some of the learners' main challenges. Content area instruction provides a meaningful context for English language and literacy development, while language processes serve as a vehicle for understanding academic content (ibid).

Similarly, Kinchin (2000) commented that experiential and concrete examples should be presented as part of in-class processes in order to improve learners' conceptual understanding and level of attainment in biology. He went on to say that different grammatical and reasoning patterns exist between everyday language and scientific language and makes it difficult for students to make sense of information they receive in school and at home. He reasoned that biology teachers need to understand that distinction to better identify students' preconception. This applies to respiration and to exploring ways to support biology learners to make conceptual changes. To demonstrate such an understanding involves showing the relationships between terms and concepts (Kamini, 2001). The teacher's role is thus to assist learners by showing them how certain concepts are interlinked and articulated (Koba & Tweed, 2009).

Other teaching strategies can be used to reduce the language difficulties experienced in science classrooms during teaching and learning on respiration. As confirmed by Lemke (2001) second language speakers need to practice through talking if they are to develop their proficiency in the language of science. In the same line, Probyn (2004) maintained that teachers must use ways that can develop learners' language skills in science. She suggested proper utilization of a chalkboard, whole class questions and answers, practical work and code-switching as approaches for language support which aim at effective mediation to close the gap of concepts developmental needs. Roberts (2004) supported the use of practical works and Millar (2004) maintained that practical work helps learners to understand concepts better. On the other hand, Bencze (2000) proposed other mediational ways that can help teaching and learning to be effective for second language learners. These were: the effective use of chalkboard by writing down new terminologies for learners, which involves another sense of seeing rather than hearing only, and motivating learners to build their own glossary on this topic.

2.3.4 Practical activities

The use of practical activities in the science classrooms has been argued to be profoundly important in mediation of learning. The Namibian curriculum of the Ministry of Education (2010) stated that:

> *Teaching and learning should be characterised by critical thinking, investigating phenomenon, interpreting data, and applying to practical skills and abilities which are essential to understanding the value and limitations of natural scientific knowledge and methods, and their application to daily life (p. 2).*

According to Millar (2004), practical work or laboratory means any teaching and learning activity which involves students observing or manipulating real objects and materials in their subjects under the supervision of their teachers. In agreeing with the curriculum statement, Millar (2004) summarised the importance of practicals in this way:

> *Since humans construct sophisticated and powerful representations of the world by acting on it in the light of our current understandings, therefore modification of these in the light of the data it generates, then practical experience of observing and intervening in the world is essential for understanding. Furthermore, practical work is necessary for developing students' understanding of scientific concepts and explanations (pp. 7 &11).*

Millar (2004) noted that observation or manipulation of objects could take place in a school laboratory or in an out-of-school setting such as the students' home or in the field, in both settings the aim is to help learners understand concepts. As an example, exposing learners to indigenous ways of knowing such as brewing of traditional '*oshikundu*' , '*olambika', 'otombo',* can extend their knowledge and open up for scientific knowledge of brewing of beer. Millar (2004), claimed that visualisation of real objects and situations promote understanding while at the same time alternative conceptions are confronted and refined or replaced during practical activities.

Roberts (2004) proposed five various categories of practical activities namely; practical tasks requiring skills, technological, investigations, observation and exploratory tasks. He added that exploratory activities help learners to be creative (p. 115). In their study conducted in the Eastern Cape province of South Africa, Maselwa and Ngcoza (2003) referred to practical work as 'hands-on', minds-on' and 'words-on' activities. They submitted that learners feel empowered if given opportunity to engage in hands-on activities, and this promotes conceptual development and understanding of science through gradually reducing the degree of rote learning. Their study categorised practical work as one of the aspects which learners enjoyed and kept them in science classrooms when it is taught in a mode worth emulating. Maselwa and Ngcoza (2003) also suggested that to promote meaningful learning, science teachers should involve learners in doing practical work.

Hattingh, Aldous and Rogan (2007), added a significant contribution by giving examples of practical works, which they categorised as 'exercises', 'experiences', investigations' and 'illustrations of theories'. Though practical work can contribute to meaningful learning in science, Hattingh, et al. (2007) commented that whether practical work will be conducted, and what types of practical work will be used, depends not on the intentions of policy documents but on the decisions of science teachers. They emphasised that teachers who are motivated to do practical work will always find ways to carry out and demonstrate practicals with their learners even in the most poorly resourced schools. Conversely, those who are not self-motivated will not carry out and demonstrate practical works even where there is rich availability of resources (p. 89).

Hattingh, et al. (2007) however cautioned teachers not to equate hands-on activities with learning, they should therefore always be careful to select scientific concepts they intend to develop in their learners through using practical work. Thus, they recommended that practicals should be planned well in advance with proper instructions if they are to serve their intended purpose. Hodson (1990, p. 33) claimed that laboratory work gives learners an opportunity to develop from concrete situations to abstract ideas and so minimize confusion. According to him, practical activities can be a vehicle for arousing curiosity and appreciating the aesthetic quality of different aspects of the subject presented to learners. In contrast, some practical work conducted in schools is not carefully planned, causing chaos, not yielding positive outputs, providing little or no real educational value and thus unable to justify the often extravagant claims made for it (ibid, p. 39).

While Rudd, Greenbowe and Hand (2007) believed that practical work can minimize confusion in teaching science, Hodson (1990) argued that practical work carried in school is 'ill-conceived, confused and unproductive' (p. 33). In his view, 'hand-on' practical work does not guarantee learners' motivation in science classrooms' lessons. He claimed that learners may find some practical activities uninteresting, demotivating and extremely boring. To validate his expression, Hodson (1990) reasoned that laboratory work can only be useful if and only if learning is taking place. In the same way, Roberts (2004) cautioned that practicals that are aligned routinely can retard learning and generate misconceptions among learners. Thus, other alternatives supplementary to practical activities may be expanded and can be useful in response to this challenge.

Hart (2003) argued that hands-on activities are less dependent on formal mastery of the language instruction, and thus may reduce linguistic burden on ESL learners. This will also improve on the learners' performance in paper 3 for practical examinations at NSSCO level, if they are well oriented to hand-on activities. I would agree with Hart (2003) that teachers should explore ways to help learners engage in hand-on activities as another way to improve learners' conceptual understanding in Biology, particularly in respiration. The above discussions emphasise the need for teachers to prepare practical activities well in advance and to allow learners' inputs to affect learning. This helps them to make sense of concepts, since most of their senses are involved during practical activities and that may contribute to information retention as well as their retrieval rate.

In a study conducted in Nigeria, Ogunleye and Babajlde (n.d) found that gender has also continued to be an issue of general concern to educators and researchers and this is evident from their reports. They noted that science and technology is a male-dominated subject and that females tend to shy away from scientific and technological fields. They added that girls in single sex schools acquire more and better practical skills than their counterparts in mixed-sex schools and it could be therefore inferred that scores in practical skills are gender-dependent.

I did not find any study that looked at practical activities specific to respiration through gender lenses and this could be a research gap.

The next sections provide the theoretical framework guiding this study. I start by describing mediation of learning and tools that are considered useful in mediating learning in science. Lastly, I discuss social constructivism and pedagogical content knowledge (PCK).

2.4 Theoretical frameworks

According to Merriam (2009), a theoretical framework is the structure on which a research project is focused. The framework of any study determines aspects of the research such as the research problem, methodology undertaken, data analysis and how the data can be presented and interpreted. The theoretical framework originates from the concepts, theories and literature of a specific discipline as these apply to a research project.

The theoretical model used in this study was composed of three models; Vygotsky's Mediation of Learning, social constructivism and Shulman's pedagogical content knowledge (PCK). These are discussed in turn below.

2.4.1 Mediation of learning

Vygotsky's theory of mediation of learning is a focal point in this study. It incorporates the 'zone of proximal development' (ZPD). Vygotsky (1978) explained that the ZPD is the difference between the actual development reflected by an individual learner in solving problems and the degree of potential development. This zone can be seen by the teachers as they engage in assisting the learners.

Corresponding to Vygotsky's view, Doehler (2002) perceived that cognitive development can be achieved by the expert during learning activities, in this case a teacher. Mediated learning occurs as a result of the interaction between a teacher (an expert) and a learner (a novice) in a sociocultural setting. Meaningful instructions allow students to make links between the past, the present and the future.

Vygotsky (ibid) chronicled the major role mediation plays in ways learners think in a social context. He focused on a variety of mediational tools needed for higher order thinking and actions to take place, arguing that utilizing different material tools such a posters and chalkboard may have indirect impact on psychological tools which include the use of a language.

Thompson (2013) concurred with Vygotsky and advocated that speaking and writing in a specific language is essential for intellectual development.

Vygotsky (ibid) emphasized that learning mediation includes the use of cultural artifacts, tools and symbols including language, and these play important roles in the formation of human intellectual capacities. He added that when teachers use mediational tools to scaffold learning development of learners, close attention should be paid to their ZPD, because learning take place within a ZPD. Departing from Vygotsky's approach to mediating learning, I shall now discuss Presseisen's theory and attempt to find correlations or gaps between the two.

Presseisen and Kozulin (1992) defined mediation of learning as a subtle interaction between teacher and learner in the enrichment of the students' learning experience (p.1). Mediation therefore refers to the comprehension of knowledge in sharing experiences and is a key to success in education. They viewed mediation as the use of language as an instrument of thinking where the mediator helps the learner to frame, filter and schedule the stimuli (ibid). They acknowledged that mediation of learning is the link between the teacher and the learner which brings forth effective acquisition of knowledge and went on to describe the three types of tools through which mediation of learning can be achieved. These are psychological, physical and human mediators. Psychological tools are symbols, formulae, graphs and most essentially the language aimed at physical procedures. On the other hand, physical tools such as pen and paper have an indirect effect on psychological functions since they are externally manipulated by human beings. In short, these tools function interdependently.

Unlike Vygotsky's theory, Feuerstein's theory of mediated learning experience highlights that mediated learning results from the mere existence of a task and a structured cognitive function. In his view, mediated experience and sharing of meaning is important (ibid). Presseisen and Kozulin (1992) favored Feuerstein's theory, after they have conducted a study in which Vygotsky's mediated learning yielded poor results. They found that only a few students were able to give correct responses after an exercise, the majority remaining with their prior misconceptions. Fraser (2006) asserted that mediation of learning entails the intervention or mediation of experiences through the intention of a mediator who selects and organizes the learning environment for the learners in a chronological order. He recommended that mediation should produce in learners a natural tendency to learn how to learn (ibid, p.9), in the Mediated Learning Experience (MLE) as articulated by Feuerstein.

Feuerstein theory has also identified the qualities of effective mediation. First, is the deliberate action of a teacher to assist the learner to comprehend, which is at the centre of learning. Second, what a mediator (teacher) can do to help a learner (novice) to grasp the meaning and the relevancy of what they are learning. Third, the teachers must find a way to help learners to apply new acquired knowledge.

Other mediational tools or teaching strategies that help learners to make sense of biological concepts are also relevant to this study. Hoabes (2004) defined teaching strategies as instructional techniques teachers' use which should enable learners of different cultures and abilities to progress. She saw the need for teachers to teach learners to think critically and independently. She then expatiated on the need to expose learners to decision making and be guided to seek information to undertake inquiries, and engage in action to take responsibility for their own learning (ibid, p. 14). This means that biology teachers should design inquiry activities that allow learners to expose themselves even to activities such as a traditional way of bread making and brewing in their communities. Such an opportunity may initiate greater connectedness of home and school science as illustrated by Kibirige and Van Rooyen (2006). They maintained that moving from known (everyday experience) to unknown (new information) can promote a smooth cross over.

Some teaching strategies proposed by Koba and Tweed (2009, p. 140), included concept maps, annotated diagram, cartoons, and analogies. These were claimed to help students to change their preconceptions for conceptual understanding (ibid). Through using these strategies students will be engaged in the learning process and motivated to deal with the concepts. These strategies also require learners to grapple with their ideas, thus serving a metacognitive function. Koba and Tweed (2009) found that annotated drawing tends to involve more students in the learning process, for several reasons: firstly, students who might not express themselves in words are given different options for expression. Secondly, students are free to choose what they draw and their illustrations can be drawn from their own experiences.

Similarly, concept cartoons have several advantages: firstly, they create an environment that promotes participation in class discussion and lessens students' anxiety over the wrong answer. Secondly, they encourage cognitive confidence through requiring students to consider explanations for the situation in the cartoons, confronting their own and their peers' preconceptions. Finally, they may lead naturally to decisions about possible investigations. Thus, teachers are urged to explore concept cartoons and see if they can work for their learners as well.

Koba and Tweed (2009), viewed concept mapping as an effective way to support conceptual change and require students to show relationships among concepts. On the same subject of teaching strategy, Tekkaya (2012, p. 264), applauded the concept map as an effective way to identify relationships between concepts. Concept maps serve to clarify links between new and old knowledge and enforce the learner to externalize those links and this facilitates meaningful learning (ibid, p. 264). Agreeing with Koba and Tweed (2009), Tekkaya (2012) remarked that concept mapping and annotated drawings are effective at eliciting learners' preconceptions. In order to develop successful learners, teachers must identify prior student conceptions and research-identified misconceptions related to the concept being taught. This can help them to identify appropriate instructional approaches, get rid of those misconceptions and promote learners' conceptual understanding (Koba & Tweed, 2009).

Koba and Tweed (ibid) emphasised the importance of learners establishing links and constructing patterns, which depends heavily on their prior existing knowledge. Hence, teachers must provide opportunities for their learners to express and conflict their own preconceptions and those of their classmates, if learners are to develop conceptual understanding. According to Koba and Tweed (2009, p. 125), other strategies that teachers can use to engage learners with scientific ways of knowing include but are not limited to the following: asking questions, inferring from data, challenging each other's ideas, communicating inquiry results and synthesising learners explanations with scientific explanations.

These authors however, cautioned teachers to talk about and use the correct terminologies for the concepts being learned. The diversity and richness of experience and expertise that children bring to school be recognised, bearing in mind that their cultural values and practices may be different from those of their teachers, so a range of 'scaffolding' should be provided to support learning. The degree of support needed vary over time, context and the degree of content complexity (Hodgskiss, 2007, p. 22)**.**

Corresponding to that, Tekkaya (2012, p. 264) described a conceptual change text as an instructional technique that creates conceptual change on students' minds while promoting meaningful learning. Conceptual change texts are designed to make students aware of both their misconceptions and scientifically accepted concepts. Misconceptions are directly stated within the texts and help students to understand and apply the target scientific knowledge through the use of more plausible and intelligible explanations (ibid, p. 264). Tekkaya (2012) further explained that a conceptual change text strategy not only helps teachers to analyse the ideas of their students but also helps learners to get a better understanding of biological concepts, thus this technique can be useful in science teaching.

In the same vein, Harrison and Treagust (1996) suggest possible useful models in science, including analogical model, chemical formulas, maps and diagrams. In this section only analogies and chemical formula are discussed because models have already been presented. Analogies can be extracted from real world experiences. They can mediate learners to digest and assimilate concepts on respiration. Concrete examples are useful in respiration, so that learners can compare the taught concepts with the situations experienced, which help them to understand the topic better. For example, chemical formula can model the composition of molecules and analogies can be used to illustrate abstract patterns and the relationship between photosynthesis and respiration.

In contrast, Harrison and Treagust (1996) argue that analogies can be frustrating for learners whose reasoning skills are relatively limited. The learners facing difficulties struggle to compare and contrast essential aspects presented by the analogy. For example when learners are challenged to differentiate between anaerobic and aerobic respiration in terms of the amount of energy, their problems may be compounded by transfer of incorrect information. Since analogies are often easier to recall, learners may end up only remembering the analogies at the expense of the concepts intended to be learned and consequently, they may express wrong concepts in the examination and so perform poorly.

Likewise, textbooks can be also useful to mediate learning, most importantly if they contain glossaries of new and unfamiliar words. Also if textbooks show new meanings in brackets, that can be a way of supporting learners to use the textbook effectively. It is for these reasons that Nakale (2012) referred to the textbook as a 'teacher helper'.

2.4.1.1 Mediation of learning within Vygotsky's Zone of Proximal Development

Vygotsky (1978) shared some benefits to both teachers and learners when teaching within the ZPD. Such teaching includes challenging but reasonable tasks that stimulate thinking and motivate learners to make efforts to learn. Teaching within the ZPD provides meaningful instruction and feedback that drives further development at an appropriate pace and values individual or collaborative groups (ibid, p. 89).

According to Vygotsky (ibid), mediation also helps teachers to engage learners in social interactions to enable learning and better understand students as individual learners, as learners in a small group or large group setting. Vygotsky's Zone of Proximal Development (ZPD) is well known, acknowledging the importance of interactions and collaboration. The ZPD centres on the idea that with the help from adults, teachers or peers who are more advanced, students master concepts and ideas they might not understand on their own. In the same vein, Lui (2012, p. 2) described the ZPD as the difference between what a child can do independently and what he or she is capable of doing with targeted assistance (scaffolding). The Vygotskian theory thus views teachers as important in navigating learners in the ZPD through scaffolding methods, apprenticeship and enculturation (Hodson & Hodson, 1998).

Goos (2004) noted that the learner's independent problem solving capability can be improved and a higher level of performance can be achieved with expert guidance. Teachers who are offering help to learners are already capable of performing the activity and so are considered more knowledgeable others (MKO). In addition to Goos' (2004) ideas, Virkkunen and Newnham (2013) talked about *double stimulations* in the Vygotskian mediation process, as the introduction of natural objects into the task of problem solving. This foregrounded the teacher as an organiser and facilitator, using a variety of scaffolding to help learners to learn.

In looking at the interaction between learning and development, Vygotsky (1978) considered that initially children will be able to learn much more in collaboration with others than they will be able to achieve alone and that this learning will then feed back into future learning situations. This gap between what children can achieve collaboratively with others and what they can achieve individually is Vygotsky's ZPD (as cited in Hodgskiss, 2007, p. 10). In support of Hodgskiss (2007), Kahenge (2013, p. 28) asserted that "teachers play a critical role in scaffolding learners to understand concepts they are taught."

As learners interact with their teachers through discussions and collaboration, they are moving from one level to another, of their ZPD (Kahenge, 2013). As conceptual development and understanding occurs and learners can solve problems beyond their unassisted efforts, then a teacher can gradually withdraw the support and learners become capable of working independently.

Hodgskiss (2007) and Nakale (2012) also shared this sentiment in their social perspective. Drawing on Vygotsky's work (1978), they observed that one comes to internalise what one learns through social mediation by a more knowledgeable others (the peers or the adult). The ZPD is meant to focus attention on the relation between instruction and development while being relevant to many other problems of mediation (Chalklin, 2003, p. 1). In this case as alluded to earlier in this Section, teachers are considered to be the more knowledgeable others who ought to determine the level of learners' development and then determine their tasks accordingly (Nakale, 2012).

Carrier (2005) added a significant dimension to this study. One suggestion that he made, was that teachers should scaffold English Language Learning (ELL) learners by providing sentence frames to develop the ability of learners to use science vocabulary in grammatically correct and fully formed sentences in science. As learners become proficient in the use of language and literacy skills, teachers can gradually withdraw some of their sentence framing support.

2.5 Social constructivism

Vygotsky's (1978) mediation overlaps and complements social constructivism, which he considered to have an effect on learning. According to Vygotsky, learning can effectively take place in an organized social set up organized to interpret and construct meaning, such as the classroom, as discussed (Section 2.4.1.1).

Social constructivism is widely advocated in science teaching and learning. Matthews (1993, p. 359) stressed on the "pupil engagement in learning" rather than the pupil being a merely passive recipient of knowledge. This means that learners should be actively involved to see how things are done and be able to implement what they learn in their everyday life. The classroom can be regarded as a community of practice (Lave & Wenger, 1991), where teachers, learners and community member share resources and participate fully and where learners take responsibility of their own learning (Vygotsky, 1978), such as finding solutions to their own problems.

McRobbie and Tobin (1997) defined social constructivism as a constructed knowledge which is socially mediated as a result of cultural experiences and interaction with others in that culture. They further elaborated that individuals' constructions are mediated by the actions of others in a social setting and characteristics of the culture in which learning is situated. A social constructivist perspective on learning emphasizes the importance of making connections between experience and extant knowledge. McRobbie and Tobin (1997) advocated that teachers should give learners freedom during mediation, and that the learning content should be contextualized to the learner's needs.

It was considered worthwhile to adopt a social constructivist framework for this study, seeing that Hodson and Hodson (1998) insisted that social constructivism influences high cognitive development. Since the study investigated the mediation of learning in classroom settings, the social constructivism approach was relevant. Social constructivism emphasizes that learning is an active social process in which individuals make meanings through interactions with each other and with the environment they live in. Knowledge is thus a product that humans can construct, socially and culturally in their communities (Hodson & Hodson, 1997). Moreover, they argued that the constructivist perspective sees knowledge as actively constructed by individual, groups and society not simply transferred (Hodgskiss, 2007, p. 11). One of the key concepts of social constructivism is the notion of mediation.

Hodgskiss (2007) argued that a social constructivist's teacher considers herself to be an active participant with learners in constructing their learning. The teacher has to design and set up an appropriate context in which learners will engage in interesting activities that encourage and facilitate learning. Hodson and Hodson (1997, p. 11) further asserted that the social constructivist perspective is important and has bearing on all aspects of teaching and learning. This perspective is also a central underpinning of the Learner Centred Education (LCE). In LCE science learners, specifically Biology learners can learn together in small groups to share and communicate ideas and their findings in mediated activities.

Moll (2002) advocated that social constructivism places the learners at the centre of learning by taking account of the experiences learners bring to classroom as required by the Namibian curriculum (Section 2.2.1). This facilitates a progressive move from rote learning to learning with comprehension. Moll (2002) supported Hodson and Hodson (1998), by illustrating the importance of Vygotsky's theory of social constructivism in the mediation of learning process and acknowledged that learners can construct meanings with the help of experts, who in this case are the biology teachers. In creating the scaffolding to mediate learning, learners' 'Zone of Proximal Development' should not be ignored. Collaborative learning is also important in mediation of learning. To support that, Vygotsky (1978) reasoned that specific concepts can be learned in indirect ways. He posits that cooperative learning yields better achievement during mediation. Goos (2004) insisted that teachers need to have proper knowledgeable guidance to scaffold their learners to solve problems within their ZPD (Vygotsky, 1978).

Matthews (1993) claimed that while individuals develop their own understanding, knowledge is socially mediated. Lending support to Matthews, Windschitl (2002) argued that social constructivism recognizes the importance of "social and personal aspects of learning" (p. 131). For example, learners can construct their individual knowledge when they are provided with opportunities to negotiate with others in a social situation.

The quality of classroom language is also a particular concern of a Vygotskian teacher, and some constructivists agreed that logical thought is expressed through language. Therefore, language practices, in this case applied to English as a second language medium of instruction as well as being a scientific language, are an important part of classroom activity. Prince, Handley, Millar and Donovan (2010) qualified that learners learn best when actively engaged in the learning process. They prioritized active approaches as more effective in developing learners' ability for higher order thinking tasks such as analysis, synthesis, and evaluations. This kind of thinking is required to achieve the critical outcomes stated in the Namibian National Curriculum for the Ministry of Education (2010) discussed in Section 2.2.1.

Ndafenongo (2011, p. 25) posited that active learners' involvement in meaningful classroom activities rather than mere listening, can help learners to think about what they are doing. For example, the TESSA reports (2012) proposed that during mediation of respiration the teacher can take learners outside for an exercise. Then soon after the exercise, learners can measure their pulse rates. This illustrates that a lesson should be related to learners' real world. Ndafenongo (2011) further asserted that knowledge is not merely transmitted verbally but must be constructed and reconstructed by the learners. Ndafenongo (ibid, p. 26) further contended that active learning takes place when the activities are interactive, simple to understand, have a short defined time frame, are creative, relevant and motivational and are sometimes collaborative. Pratt (2002) believed that knowledge is not passively transmitted or received but actively built up by the receiver. Learners come to biology classrooms with considerable experience about nature hence their input must be valued.

In spite of these advantages of social constructivism, this theory can create a predicament. As discussed in section 1.2.2, time frame as one of the teachers' challenges put this theory to be demanding to implement. During mediation in a social constructivist framework, learners are supposed to be at the centre of learning (Vygotsky, 1978). Simultaneously, they are required to complete a large content of exam-driven syllabus in a short time (Mwetulundila, 2009), which creates an awkward situation for both teachers and learners. Moll (2002) critiqued that social constructivists have ignored other aspects such as the force of practical circumstance. For example, social constructivists do not talk about how learning should be framed considering different environmental conditions and how individuals learn. McRobbie and Tobin (1997) added that the social setting should not be the only way that can enhance learning but it can also inhibit mediation of learning.

On the other hand, Hodson and Hodson (1998) believed that scaffolding involves the teachers or the more expert adult or peer controlling the learning task so that the learner is able to solve a problem, perform a task or achieve a goal that would be beyond their unassisted efforts. To add weight to their argument, they identified effective ways to scaffold learners which included the following aspects: firstly, take into account the status of the leaners, developmentally and in regard to their understanding of and ability to complete the task. Secondly, use explicit instruction as an essential element of any learning (ibid). Keep learners within their zone of proximal development (ZPD), by giving tasks that are slightly above the level of those they can accomplish alone (Lee, 2011). Lee (2011, p. 38) postulated that scaffolding techniques are the means by which the more knowledgeable other, a teacher in this case, guides the learners within the learners' own zone to reach greater understanding and mastery of the task.

Bligin and Geban (2006) add that the use of outdated teaching approaches such as teacher talk do not enculturate or promote conceptual understanding in science. Instead, they proposed collaborative learning approaches in assisting learners to comprehend concepts they are learning. In the same vein, the TESSA report (2012) underscored that teachers should develop the habit of relating all the areas of science that they teach to their learners' everyday lives before moving on to consider issues of wider importance to society as a whole. The TESSA (2012) report remarks that one of the best ways of making learners to see the subject as relevant to them is to relate it to their own bodies (Section 2.2.1).

The next section presents the Pedagogical Content Knowledge (PCK) theory of what teachers need to know about their subject they are to teach. I will start by describing what PCK is and its significance in teaching and learning of science, in the context of this study.

2.6 Pedagogical Content Knowledge in the mediation of learning in science

Shulman (1987, p. 15) describes Pedagogical Content Knowledge (PCK) as the capacity of teachers to transform the content knowledge in their possession into forms that are pedagogically powerful and yet adaptable to the differences in learners' ability and background. Thus, Shulman suggested seven categories of knowledge that teachers should possess to promote comprehension among learners (Van Driel, Verloop & de Vos, 1998). These categories are: content knowledge, pedagogical knowledge, knowledge of learners and their characteristics, knowledge of educational contexts, curriculum knowledge and knowledge of diverse interests and abilities of learners (Shulman, 1987).

Shulman (1987) went on to argue that PCK "represents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organised, represented, and adapted to diverse interests and abilities of learners, and presented for instructions" (p. 8). Though PCK was originally an idea of Shulman (1987), Kind (2009) has also contributed to the expansion of Shulmans notion. This study was largely guided by Shulman's interpretation of PCK, though other references were also used.

Shulman categorised the knowledge base for teachers into three: content knowledge of a subject, pedagogical content knowledge, and knowledge of the curriculum. He referred to subject content knowledge as "an amount and organisation of knowledge in the mind of the teacher" (ibid, p. 9). This amounted to a caution to teachers that they do not only need to know the basic content of the subject, but also have a deeper understanding so as to be able to present the content argument. Secondly, pedagogical content knowledge implies distinctive appropriate examples, illustrations, analogies and explanations teachers can make use of to make the subject content inviting and reachable to the majority of learners if not all (ibid). Thirdly, the curriculum knowledge should enhance the learning material developed for a specific subject and grade in order to help in grasping the subject matter. Other strategies that Shulman (1987) felt can be useful are: knowledge of learners, their backgrounds and their characteristics.

Consistent with Shulman's views, Kasanda, et al. (2005), advanced the incorporation of learners' prior everyday experiences by embracing their individual differences and empowering them to be in charge of their own learning. Agreeing with this too, Loughran, Mulhall and Berry (2004) put forward that PCK is the information which teachers can use in the mediation of learning. This means that teachers do not only need basic knowledge on a specific subject but professional knowledge is a prerequisite in teaching. Shulman (1987) claimed that teachers need to have knowledge of the best strategies on how to mediate learning of specific topics if learners are to comprehend the topic and get rid of certain alternative conceptions. According to Shulman (1987, p. 4), there exists a knowledge base for teaching and this kind of content knowledge and pedagogical strategies are necessarily interacted in the minds of teachers. Shulman (1987, p. 7) went further to emphasise that:

> *The teacher can transform understanding, performance skills, or desired attitudes or values into pedagogical representations and actions. These are ways of talking, showing, enacting, or otherwise representing ideas so that the unknowing can come to know, those without understanding can comprehend and discern, and the unskilled can become adept.*

PCK as a construct requires teachers to have different categories of knowledge bases such as the content knowledge, pedagogical knowledge, knowledge of learners and their characteristics, knowledge of educational contexts and curriculum knowledge (Shulman, 1987, p. 8). Furthermore, teachers are expected to understand what they teach and when possible, to understand it in several ways (ibid, p. 14). Van Driel, Verloop and de Vos (1998) considered PCK as teachers' knowledge developed through an integrated process rooted in classroom practice, and that it includes knowledge representation of subject matter, understanding of specific learning difficulties and student conceptions. They noted that such a definition implies that prospective or beginning teachers may have little or no PCK at their disposal.

Geddis, Onslow and Oesch (1993) added another dimension to the definition of PCK, as "content-specific pedagogical knowledge" (p. 582). They considered PCK as a knowledge that plays a role in transforming subject matter into forms that are more accessible to students and it should consider learners' prior knowledge (ibid, p. 583). PCK considers learners' preconceptions, and science teachers were advised to refrain from approaches that are unproductive to revise misconceptions. Thus, PCK is a blend of content knowledge and pedagogy where concepts are presented to suit learners' individual differences in terms of their abilities and interests.

Mavhunga and Rollnick (2013, p. 115) acknowledged that teachers should have a capacity to transform the content knowledge they possess into forms that are pedagogically powerful. Pedagogy refers to the general ways and principles of classroom organisation used across the educational curriculum to effect mediation. They went on to stress that learners' prior knowledge (their conceptions), are what makes a topic difficult to understand, which led them to advise that representations such as analogies, and conceptual teaching strategies should be closely examined for a proper remedy. Geddis, et al. (1993) contended that teachers should transform subject matter content into forms that are accessible to their learners by drawing on diverse kinds of PCK (p. 575).

Shulman (1987) emphasized that mediation of learning should take note of the need to transform learners through lesson preparation and instruction. Lesson preparation requires teachers to choose the content, structure and the logical method of the lesson presentation to introduce key concepts to learners. For instance, mind maps, illustrations, demonstrations and cartoons can be used to promote learners' conceptual change. During mediation specifically in the lesson presentation, classroom environment must be conducive for good interaction and learning. Therefore, merely have teachers who are academically qualified does not guarantee that they are effective teachers if their PCK is not strong enough (Loughran, et al., 2004).

It was however acknowledged by Loughran, et al. (2004) that the lack of connections between practice and knowledge have proved to be exceptionally difficult; for many teachers, their practice and knowledge/theories that are supposed to influence that practice are far different from each other, a huge gap persists (p. 371). Furthermore, Mellando, Bermejo, Blanco and Ruiz (2007) found contradictions on the relationship of between teachers' epistemological beliefs and their classroom practice, caused by the pressure of classroom situations. They argued that the demands of time, curricula and student achievement create a focus more on doing than on explicating the associated pedagogical reasoning.

Kind (2009) put forward that during mediation of learning, the PCK aspects inclusive of the content, interest and the context, must be taken into consideration during teaching. An infusion of subject matter knowledge (SMK) and teaching strategies that acknowledge learners' background is required. Furthermore, Kind (ibid) pointed out that PCK theory is relevant for examining and understanding of teachers' skills. He interpreted that PCK integrates various components during teaching and learning. These components include: learners' difficulties, the nature of science, sociocultural aspects, curriculum knowledge, SMK, context and subject specific learning. Citing from Van Driel, et al. (1998) that teachers' knowledge is complex in nature, it is for that reason that data gathered in this study were triangulated in an attempt to get insights into teachers' PCK when mediating learning of respiration.

Therefore, this study gave me an opportunity to see the relationship between theory and practice in science classrooms. The theories discussed here are linked to the expectations of the Namibian curriculum of education discussed in Section 2.2.1 which is a policy document guiding teaching practice in Namibian schools.

2.7 Concluding remarks

The goal of this chapter was to review the literature relevant to the mediation of learning respiration. I investigated a number of studies drawn from international, national and local scholars.

The predicaments experienced by learners and teachers when mediating respiration were identified and discussed. Studies have shown that difficulties that challenge the effectiveness of teaching and learning include insufficient teacher knowledge, linguistic difficulty, the abstract nature of concepts, inconsistent use of scientific terminologies, to mention a few. Possible ways of intervention to minimize these problems were put forward. Studies propose the use of mind maps, Venn diagrams, conceptual change text, effective use of practical work, collaborative learning, use of analogies, and other alternative strategies such as code-switching in response to the classroom setting.

The literature in relation to mediation of learning, the role of language, scaffolding, prior everyday knowledge and other mediational tools were discussed. Studies have found that problems exist when dealing with some of the mediational tools in the classroom. This gives freedom to teachers to be selective when choosing the mediational tools so as to take account of the suggested contexts and needs of their learners. Lastly, this chapter expanded on literature that is concerned with my study's theoretical frameworks, namely, Vygotsky's mediation of learning and social constructivism as well as Pedagogical Content Knowledge. The limitations of these theorists were noted as well.

Chapter 3 describes the research methodology employed in this study. Chapter 2 is linked to chapter 1 in that it provides theoretical lenses used to respond to the research questions. It also links to chapter 3 in that the tools for generating and analyzing data are conceived within the context of the theoretical approaches discussed here.

Chapter 3: Research Methodology

Qualitative case study is an approach that is used to dig deep to get an in-depth and a complete understanding of the bounded system of a phenomenon within its context to provide rich descriptions. In qualitative research, a variety of data is collected to ensure the validity of the research findings by examining them from various angles to construct a meaningful picture of complex, multifaceted situations (Gay, Mills & Airasian, 2009, p. 426).

3.1 Introduction

The main focus of my study was to understand how Grade 11 teachers mediate learning of respiration in Biology. On becoming a Biology teacher, I found that students believe they understand many concepts but I discovered that when tested they often did not understand. This raises questions about the effectiveness of ways that teachers mediate learning and this ineffectiveness may contribute to poor performance in grade 12 as reported by the Examiners' reports (Section 1.2). Thus, as a concerned educator I decided to conduct a case study to get an in-depth understanding as indicated in the epigraph above (Gay, Mills, & Airasian, 2009). The data collected was analysed to generate evidence of what transpires in teaching and learning of Biology in two schools. After I had read some literature, I realised that a qualitative case study approach was most suitable for this study, for reasons to be discussed in Section 3.2.2.

What follows in this chapter, is an outline of the research design and orientation, and the research process followed in conducting the study. I begin by describing the research background and provide a rationale for its appropriateness. This section also includes a discussion of the particular research approaches that were adopted in the study. The research objectives, research site, participants and data gathering procedures (instruments and methods) are outlined. This chapter concludes by considering the ethical aspects and limitations of the study.

3.2 Research design and orientation

Research design is an outline of the various stages involved in the whole research process and the data generation techniques used, together with the steps that were employed to analyse the data (Maxwell, 2012). Thus, the research design for this study entailed the underlying structure of the interwoven components for the study and implications of those components.

A qualitative orientation was used in this study involving the practices of two teachers. According to Denzin and Lincoln (2005, p. 2), a “qualitative research is a field of inquiry in its own right” and this study was informed by an interpretative paradigm blended with a participatory methodology. Cohen, Manion and Morrison (2007) maintained that an interpretative research aims to provide a rich description of the phenomenon and, if possible, to develop some explanations as well. This approach therefore allowed me to understand the real situation in the classroom setting during mediation of learning of respiration and biology in general. This approach also enabled me to develop skills and experience in the classroom situation.

Nakale (2012) indicated that phenomena and events can be well understood through mental processing and interpreting of data influenced by interaction within social contexts. His interpretation resonates well with the social constructivist theory applied to the mediation of learning which guided my study (see Sections 2.4.1 and 2.5). Hence data gathered in this study were analysed, interpreted and discussed to dig deep and get an in-depth and a complete better understanding, as referred to in the epigraph heading this chapter. In this study, an intervention was made, aimed to support the teachers to develop and extend their experiences in order to improve teaching and learning practices.

3.2.1 Interpretative paradigm

I used an interpretative paradigm in this study because of its alignment to my research goal. Bassey (1999) described a paradigm as a network of coherent ideas about the nature of the world and which, adhered to by a group of researchers, conditions the pattern of their thinking and underpins their research actions (p. 42). Similarly, McMillian and Schumacher (2010) defined a research paradigm as a framework that guides how research should be conducted.

In an attempt to develop an understanding of the ways that Grade 11 Biology teachers use to scaffold and help learners make sense of respiration. An interpretive paradigm aims at understanding the subjective world of human experiences and it is concerned with the individual’s actions or interpretation during a certain process (Cohen, Manion & Morrison, 2011).

Cohen, et al. (2011, p. 289) explained that an interpretive paradigm provides a unique understanding of real people in their setting. The aim is to understand how people interpret the world around them. Since my research objective was to gain insights into the mediation of respiration, it was imperative to critically understand teachers' views and experiences. The interpretive approach is characterised by a concern for the individual researcher (Cohen, et al., 2011) as in this case.

Terre Blanche, Durrheim and Painter (2009) reasoned that an interpretative framework uses methodological approaches which include questionnaires and observations. To ensure that my research questions were addressed, I carried out six observations in total; interviews in the form a questionnaire and some follow up questions, done telephonically with Teacher 1 and face-to-face with Teacher 2. Since interpretive research also deals with subjective data: I focused on data that existed in the minds of individuals and which was expressed verbally and non-verbally in a variety of ways. Cohen, et al. (2011) contended that interpretative research provides a rich description of the phenomenon and may possibly develop an explanation of ideas. By using triangulated methods for my data, I was empowered to interpret what participants encountered in their classrooms. I also triangulated theories, and this gave me robust lenses to generate and analyse data.

On the same point, Merriam (2009) made it clear that knowledge is acquired through interaction between the participants and the researcher in a social setting as in this case study**.**

3.2.2 Qualitative case study

As stated earlier, I carried out a qualitative case study. Conducting a case study research also gave me an opportunity to search for an in-depth data for the purpose of learning more about mediation of respiration in Grade 11 at ordinary level.as supported by (Leedy & Ormrod, 2005). Specifically, I used a qualitative case study method to understand the ways used by two teachers to mediate learning of respiration. In order to obtain significant data, I designed an interview guide which was finally expressed in form of a questionnaire. I also observed lessons in the classroom situation.

Wellington (2000, p. 90) defined a case study as a detailed examination of one setting, or one single subject, or one single depository of documents, or one potential event. Denscombe (2007) claimed that a case study research allows data validation through triangulation. I followed Creswell's (2012, p. 259) procedures of inquiry to gain insights into individuals' views and practices. To understand the teaching and learning of this topic, it was necessarily to analyse the classroom situation, the mediational tools used and the participants' perspectives.

A case study is also known to have shortcomings, including that its findings cannot be generalized, but I nonetheless chose this approach because of its depth and manageability as proposed by Creswell (2012). It provides insights into the complex world of experience from the point of view of those who experience it (ibid). To retain the integrity and reliability of the phenomenon being investigated, I made an effort to get inside the persons being researched and endeavoured to understand those individuals' own interpretations of the world around them (Baxter & Jack, 2008, p. 544). It also provided more opportunities for the researcher to form relationships with participants, which gradually led into the establishment of trust and understanding (Liamputtong, 2007). After meeting face to face, we have been in contact telephonically as well before the data gathering process began.

3.3 Research goal and questions

3.3.1 Research goal

The main goal of this study was to understand how Grade 11 Biology teachers mediate learning of respiration.

To realize this goal, the study was guided by the following questions:

3.3.2 Research questions

Main research question

How do Grade 11 Biology teachers mediate learning of respiration?

To answer the main question, I asked the following sub-questions:

Sub-questions:

1. What are Grade 11 Biology teachers' views and experiences of mediation of learning of respiration during their lessons?
   To answer this question, I administered interviews questions in a form of a questionnaire.

2. In what ways do Grade 11 Biology teachers scaffold learners to help them to make sense of respiration?
   To answer this question I analyzed documents such as the learners' notebooks and workbooks and the teachers' lesson plans. I also carried out observations (Section 3.3.3) and the lessons were video-recorded.

3. What are some of the key challenges in the teaching and learning of respiration and its concepts?
   In an attempt to answer this question, I observed three lessons from each teacher which were video-recorded and analyzed. I administered interview questions in a form of a questionnaire to gain insight into teachers' views and experiences.

4. In what ways can Grade 11 Biology teachers be supported with the mediation of learning of respiration?
   To answer this question I raised the need to co-plan practical activities in this topic.

3.4 Research site and sampling

The study was conducted at two Secondary schools which I coded as School 1 (S1) and School 2 (S2) and the circuit was given a pseudonym as Pendapala Circuit, Kunene Region. Two teachers participated in this study and were coded as Teacher 1 (T1) and Teacher 2 (T2). It was necessary to use a pseudonym for the circuit in compliance with the ethical principle of anonymity in research as there were only two Secondary schools in this circuit. These schools were government Secondary schools characterised by trained teachers, high student -teacher ratios and inadequate resources. Most of the learners in these schools were from middle and low income families. The dominant languages were Oshiwambo, English, Afrikaans, Khoekhoegoab, and

Otjiherero. Most learners were taught Afrikaans as their first language but that was not their mother tongue English was the medium of instruction.

I opted for this site because it was close to my duty station, making it possible for me to gain access to the participants in terms of distance and so minimise traveling costs. I also managed to build a relationship with the participants before the fieldwork. I drew on Denzin's (2005) point that in qualitative research, researchers study things in their natural settings, attempting to make sense of and interpret phenomena in terms of the meanings people bring to them. As a result of the trust developed, the participants were able to share information with me. The two teachers were selected from a large group of teachers in Kunene which was convenient for me; a method termed purposive sampling (Leedy & Ormrod, 2014).

Sampling decisions was made at an early stage of research planning in line with Cohen, et al. (2011) suggestions, to avoid factors that may prevent gathering needed data from the targeted population. Since the beginning of the study, experienced biology teachers were the focus of this study. Jonson and Christensen (2008) described purposive sampling as a procedure that places the researcher at advantage for data gathering. It is a way to gain easy access to participants, and to knowledgeable people (Cohen, et al., 2011). In this case purposive sampling was most appropriate to gain insight from biology teachers' views and experiences around the mediation of respiration topic. Furthermore, this research method helped to gain some insight in the teaching methods used by the biology teachers and how they help learners to make sense of biology, including practical work.

Put differently, purposive sampling consisted of sampling those who have in-depth knowledge or experience about the particular concern under investigation. To select a purposive sample, one must have a clear reason (Creswell, 1998). I used this sampling strategy because it was suitable to gain insights into the experiences of teachers who have taught this subject of respiration, at ordinary level for at least three years. This was decided with a view of understanding their roles as biology teachers to help learners make sense of this topic. Experienced teachers may be in better positions to provide insight on how to overcome the challenges that biology teachers are faced with during mediation on different topics, including respiration. The sample thus comprised of two biology teachers at Namibia Senior Secondary Certificate Ordinary level, in Pendapala (pseudonym) circuit of Kunene region.

3.5 Data gathering techniques

Multiple data gathering techniques were used at different levels of my study, when developing my context and in two phases of my main study. For my context I used curriculum documents such as the Namibian National Curriculum, the syllabus for Grade 11-12 Biology, and the Grade 12 Biology Examiners' Reports.

For Phase One, I looked at the prescribed textbooks for Biology, the teachers' lesson plans and learners' workbooks. I also did lesson observations and administered interview questions (which culminated into the form of a questionnaire) to find relevant information to address the research sub-questions 1, 2, and 3.

For Phase Two, I co-developed model lesson plans together with the two teachers and this was aimed at answering research sub-question 4. This phase was informed by stimulated recall interviews while watching the videos together with each teacher.

Next, I describe the two phases and the data gathering techniques I used in this study.

Phase One

In this phase, I used three data gathering techniques, namely, document analysis, observations and an interview (which culminated into being a questionnaire). These were aiming at answering my first three research questions: What are experiences and views of biology teachers during mediation of lessons on respiration? How do Grade 11 biology teachers scaffold and help learners to make sense of the topic on respiration? What are some of the key challenges experienced in the teaching and learning of respiration and its concepts?

According to Cohen, et al. (2011, p. 195), triangulation -which involves using two or more data gathering techniques- is crucial when studying human behavior in a real setting as was the case in this study. I used different data gathering techniques to triangulate my data and ensure its validation and trustworthiness, as illustrated below.

Table 3.1: Shows the tools, methods and the purpose for data gathered in this study

Phases and stages	**Method to gather data**	**Data gathered**	**Purpose**
PHASE 1 **Stage 1**	Document analysis of curriculum documents	1. Science curriculum: (a) What do curriculum documents say. 2. Biology syllabi and subject policy of biology: (a) NSSCO level grade11-12: content covered on the topic respiration in grade 11; and Practical work covered in grade 11on this topic. 3. Biology prescribed textbooks for grade 11-12 on respiration. 4. Lesson plans of teachers, learners' workbooks and the Examiners' report for external examination of grade 12	To find out methods suggested in teaching the topic. To find out information about the content to be covered on topic of respiration in Grade 11, practical's suggestions. To see how much assistance teachers get from textbooks in the mediation of learning of the topic To gain insight into how teachers scaffold learners in the mediation of learning, performance of Grade 12 learners especially in questions related to respiration.
Stage 2	Pilot	I piloted my interview questions with a Grade 11-12 biology teacher, not involved in my research process.	To pilot test the data gathering tools.
Stage 3	Interview questions in form of a questionnaire : two grade 11 Biology teachers completed the interview questions	The conceptions and experiences of teachers with regard to mediation of learning in respiration.	To gain some insights into the teaching strategies of teachers in scaffolding learners, how teachers elicit learners' everyday experiences and challenges they faced.

	individually.		
Stage 4	Lesson observations: 2lessons per teacher were observed. The lessons observed were videotaped for follow up)	How teachers mediated learning on respiration from the beginning to the end of the lesson.	To understand teaching practices in classroom settings and validate interview data.
Stage 5	Stimulated recall videos	As follow up on stage 3, follow up telephonically and face-to-face interviews were conducted. At stage 4, stimulated recall videos conducted with one participant to clarify any misinterpretation in the specified stages. This also informed my Phase Two.	To ensure validity and locate my insights into the participants' views of understanding. Baseline data for the planning of the lessons in Phase Two.
Stage 6	Transcribed audio and video recorded data	To get information from questionnaires and classroom observations.	For data analysis
PHASE 2	I, together with the participants, developed Two practical lessons	Was an initiative to improve teaching of respiration after reflections on the lessons taught?	To try to improve on teaching respiration collaboratively.

The various data gathering techniques are now discussed in detail.

3.5.1 Document analysis

Creswell (2012) described document analysis as the analysis of all types of written communications that may have relevant information about the problem under investigation. There was a potential to gather relevant and rich data through analyzing official education department and school documents in this study. The documents used include the Namibia National Curriculum (2010), the Examiners' reports for Biology grade 12 dated 2008-2012, the biology syllabus, prescribed biology textbooks, teachers' lesson plans as well as learners' workbooks. The first three documents were used to contextualize the study and the last three were used for the main study.

Lambart (2012) argued that analyzing numerous of documents may assist a researcher to collect rich data for the research process. The curriculum acquainted me with information on the learners' cognitive development desired during mediation of learning. The syllabus also gave me some insights on basic competencies in respiration to be achieved as a result of a mediated learning. At the same time, the syllabus indicated what practical activities should be taught in this topic. All the above documents were accessible and provided adequate information.

I also analyzed learners' workbooks to gain information about how they do things in biology and their performance of biology activities.

3.3.2 Interviews

An interview is a conversation between two or more people (Cohen, et al., 2011). In this study semi-structured interviews and stimulated recall interviews were used. Although I had hoped to do one-on-one semi-structured interviews with my research participants, they indicated that they were more comfortable to write their responses on the interview guide during their spare time and for ethical reasons I had to respect this (see Section 3.8). I was however able to do follow-up semi-structured interviews. I was also able to do stimulated recall interviews while watching videos of lesson observations with Teacher 1 from School 1. This teacher could not believe the length of the lessons she had presented and the way she had engaged in the discussions.

Semi-structured interview

A semi-structured interview is a method of interrogating where both interviewer and interviewee have opportunities to discuss and explore particular themes of their interpretation from their own points of view (Miles & Huberman, 1994). Semi-structured follow-up interview questions created opportunities for me to gather data missed out in the interview questions which had been in the form of a questionnaire (Cohen, et al., 2011). An advantage of a questionnaire is that, it gives opportunity to the participants to respond in their own spare time (ibid).

Thus, in this study participants' wishes were respected. During follow up interview, I had an opportunity to probe for clarifications on given responses as the teachers were available to talk with me. I made follow up interviews telephonically with Teacher 2 as she was not reachable physically. I discussed the follow up interview questions face-to-face with Teacher 1. Semi-structured follow-up interview questions also helped me to triangulate the data.

Stimulated recall interviews

According to Lyle (2003), stimulated recall interviews (SRI) have been used extensively in research into teaching, and is an introspection procedure in which video-recorded events of behavior are replayed to individuals to stimulate recall of their interpretation (p. 862). Accordingly, during "event recall interviews", I used probes to facilitate recall (ibid, p. 862) of the observation episodes that were replayed. By this means I was able to do stimulated recall for some lessons videoed. The stimulated recall empowered me in probing what had transpired in the lesson presentations observed.

3.3.3 Observations

Creswell (2012) defined observation as the process of gathering open-ended first-hand information by observing people and places at a research site. In this study, I observed at least three lessons for each of the two teachers to gather 'live' data occurring in a social situation as suggested by Cohen, et al. (2011). For Teacher 2, the first lesson observed was an introductory part of the focus topic and was also an opportunity for me to familiarize myself with the research site. I used observation to complement data that I had gathered from interviews and document analysis as expressed by Check and Schutt (2012).

I used an observation schedule as a guide (Appendix: 7); however, any other useful data that emerged I recorded in my field notes. In order to get rich data on most aspects of mediation of learning I tried to be a non-participant observer (Maxwell, 2008), in order to reduce bias (Leedy & Ormrod, 2014). However, there were some special moments when a teacher would refer learners' questions to me and I had to respond. I sat in a position free from obstructions to ensure that I could hear and view what was happening in the classroom and the entire presentation while taking notes. During observation for Teacher 1, the quality of recorded sound was poor as at some times she spoke very softly, but that was not the case with Teacher 2. Some observations were recorded by my critical friend however he was not available for some of the lessons. I used a cellphone to video-record some lessons and that worked well because I prepared a memory card with higher memory volume. However, it was not easy to transcribe these recordings using a cellphone; thus, I transferred the memory card content into a laptop for convenience.

During observations, I focused on items such as teaching strategies, practical work, interactions between teachers and learners and among learners themselves, use of learners' prior everyday knowledge to mention a few. I observed that during the lessons, teachers used some techniques that were not part of my observation schedule and these are discussed (Section 3.3.2). Learners also asked many unexpected questions which caused some diversions from the planned agenda, providing unpredicted data. As unexpected data emerged, I was able to collect this information. This illustrates the benefits of flexibility of observations (Leedy & Ormrod, 2014).

As discussed above, stimulated recall interviews conducted while watching the videos with the participants provided opportunities to verify and validate the gathered data. This helped to answer research questions 3, 4 and to inform my Phase Two.

Phase Two

This phase was used to address my third research question: How can Grade 11 Biology teachers be supported to improve their learners' sense making of respiration and its concepts? Phase Two was informed by the analysis of lesson observations in Phase One. I thus co-developed two model lessons (see Appendix 6A and 6B) with the two teachers to be used to teach the topic respiration. During this process, the discussions were video-recorded with the permission of Teacher 2.

Within the limited scope of this study the two teachers were not required to teach the two practical model lessons. However, Teacher 2 showed an interest to implement these practical lessons for revision purposes when schools re-opened in September 2014. Unfortunately, I could not observe these lessons as Teacher 2 was unable to contact me on time in order to observe the practical presentation. She said, due to her own time constraints, she had only managed to do a practical activity on baking and bread-making as that does not require a long process.

3.3.4 Pilot Study

The pilot study gave me confidence in my data gathering techniques by ensuring alignment with the research questions as reflected in the pilot test (Appendix 3A) (Cohen, et al., 2011). I piloted my interview questions with an experienced Biology teacher from Negumbo Secondary School in Omusati region of Namibia and this enabled me to refine my instruments.

Surprisingly, during actual observation I found that some of my interview questions had not been answered in detail, and I applied follow up interview questions as discussed in Section 3.3.2. Through this means I gained confidence and the ability to use different strategies for probing responses during the stimulated recall interviews.

3.4 Data analysis

Gay, Mills and Airasian (2009) described data analyses as procedural structures followed by a researcher in scrutinizing the raw data to make sense of it. I used data analysis procedures to answer the research questions in Section 3.3.3., and these were derived from the themes that emerged during the data gathering process. In addition, Cohen, et al. (2011) point out that:

> *Qualitative data analysis involves organizing, accounting for and explaining the data; in short, making sense of data in terms of the participants' definitions of the situation, noting patterns, themes, categories and regularities (p. 537).*

Data analysis in this case study involved a multi-stage process of organizing, coding and categorizing, synthesizing and summarizing data (Cohen, et al., ibid). I used the following data analysis procedures: The audio recorded lessons were transcribed into text. This was my first experience of transcription and I discovered that it needed considerable time and demanded effort. I analyzed data using a colour coding techniques by segmenting and labelling text to identify descriptions' and broad themes in the data as proposed by Creswell (2012).

Different colours were used to code the themes that emerged from the data, using green, pink, red, purple, yellow and orange. The theme on how do Grade 11 biology teachers scaffold learners to help them make sense of respiration and its concepts was represented by green. The theme on key challenges faced by biology teachers was represented by red and the theme on how can biology teachers be supported to improve learners' sense making was represented by orange.

Since Vygotsky's (1978) Mediation of Learning and Social Constructivism as well as Shulman's (1987) Pedagogical Content Knowledge (PCK) informed this study as a framework for mediation of learning, these were focused during data analysis. The framework used helped me to analyse the data, because during mediation participants' activities were observed in a natural setting. Teacher-learner interactions were the main theme for mediation of learning (social constructivism perspective), hence during analysis I paid more attention to moments where interactions evolved.

During data analysis I was keen to know how teachers made use of learners' prior everyday knowledge when mediating learning and I used PCK to gain insights into teaching and instructional strategies used by teachers. I also used PCK to understand the content knowledge the two teachers applied to mediate learning. I also concentrated on how teachers dealt with the challenges faced by themselves as well as their learners in science classrooms. I used social constructivism blended with PCK to understand how two teachers helped learners to comprehend respiration concepts. I compared the data generated with literatures, made interpretations, discussed and drew conclusions.

3.5 Data validation and trustworthiness

Validity is important in any research; derivation of data from more than one source determines the credibility of the findings (Cohen, et al., 2011). Triangulation was used to ensure that the data obtained was credible (Hamilton & Corbett-Whittier, 2013). This study used the following data validation steps to authenticate the research:

Firstly a pilot study was carried out in another school with a biology teacher to validate the data gathering techniques. Piloting provided an opportunity to refine the research instruments so that the intended data was gathered. Though a pilot study was done, follow-up questions were necessary to collect rich data because the interview questions were semi-structured and were culminated into the form of a questionnaire as teachers felt more comfortable to give responses in writing on their spare time due to time constrains.

Secondly, stimulated recall interview with the participating biology teachers were used to clarify discussion of their teaching practices and their conceptions were used as proposed by Lyle (2003, p. 861). Thirdly, the study used multiple data gathering strategies such as triangulation and member checking to give me an opportunity to understand the whole process of the research which a single method would not reveal (Cohen, et al., 2011), thus, enhancing validity.

Creswell (2012) defined member checking as a process in which the researcher and participants involved in the study check the accuracy of data gathered. Thus in this study I requested the participants to read through and check whether the interpretation of transcripts were truly reflected and represented their input. The aim was to give participants an opportunity to confirm or deny the researchers' interpretations and conclusions.

3.6 Ethical considerations

Hamilton and Corbett-Whittier (2013, p. 64) defined ethics as the "norms of conduct that differentiate between acceptable and unacceptable behavior". In this study, written consents were obtained for all the protocols involved as discussed below. Therefore, I conformed to basic ethical principles as described by McMillan and Schumacher (2006, pp. 420-422) in conducting the study.

I sought permission from the Director of Education in Kunene region, the school principals, the Head of Departments for science, the two biology teachers as well as from the parents of the learners who were involved in this study through their teachers. The consent letter clearly explaining the aim of the research was given to the participants. Cohen, et al. (2011) asserted that informed consent takes place when individuals decide whether they still want to participate in an investigation or study after they were informed of all aspects that could have an impact on their participation. This guided the decision to write the consent letters to participants.

Interview questions were discussed beforehand and were turned into a form of a questionnaire to respect the participants' wishes. In the consent letter, it was indicated that the interviews and lesson observations were to be videoed and audio-recorded for the purpose of the study only. Furthermore, participants were urged to give truthful information as the outcome of the study would have significance to them and would collectively inform crucial interventions to the benefit of others. I established a good rapport and a good level of trust with these teachers and this helped me to gather trustworthy data, though within a short period of time.

Throughout the research process, confidentiality and anonymity of the participants and study site were maintained by using pseudonyms so that no information could be linked to the research participants' identity. Participants' identities and that of their schools were protected using codes, and the Circuit was given a pseudonym as discussed in Section 3.4. Throughout the study, participants were continuously guaranteed confidentiality. As advocated by DePoy and Gitlin (2011), no persons other than me would have access to the participants' information. During the data analysis, no physical or psychological harm was done that might damage participants' image as Babbie and Mouton (2005) recommended.

3.7 Limitations of the study

Since this was a small scale case study research involving only two teachers in Kunene Region, its results are limited to Pendapala (pseudonym) circuit, it cannot be generalized to the whole region. These two participants could not represent the population of teachers in this circuit. However, it provided some insights into how teachers mediate the topic of respiration. I was only able to do stimulated recall interviews with one teacher as the other teacher was too engaged with school activities. Since the research participants' rapport was established within a very short period of time, this may have effect on the data gathered.

3.8 Concluding remarks

This chapter outlined the research design and methodological orientation which was implemented as a qualitative case study informed by an interpretative approach. I outlined the research questions followed by a description of sampling procedures used and data gathering techniques. I used document analysis, interviews and observations as the main techniques to generate data that enabled me to answer the research questions in Section 3.3.2. The research methods used in the research process as well as the coding methods for data analysis were explained.

This chapter presented the triangulation methods and ethical considerations and concluded with the limitations of my study. This chapter links to chapter two in that the methodology discussed in this chapter and the tools for generating and analyzing data were conceived within the context of the theoretical approaches discussed in Chapter 2.

The next chapter is the presentation and analysis of data gathered during the research process.

Chapter 4: Data presentation and analysis

> *Data analysis involves organizing the data, conducting a preliminary read-through of the database, coding and organizing themes and interpreting the data into a sense-making (Creswell, 2013, p. 179).*

4.1 Introduction

In this chapter, I present the data obtained from document analysis, questionnaires and observations as explained in Section 3.3.2. The chapter structure follows the two phases highlighted in Table 3.1 Section 3.5. The first section focuses on Phase One of the study guided by the following s**ub-questions**:

1. *What are Grade 11 Biology teachers' views and experiences of mediation of learning of respiration during their lessons?*
2. *In what ways do Grade 11 Biology teachers scaffold learners to help them to make sense of respiration?*
3. *What are some of the key challenges in the teaching and learning of respiration and its concepts?*

In the second section the focus is on Phase Two, responding to sub question 4:

4. *In what ways can Grade 11 Biology teachers be supported with the mediation of learning of respiration?*

During the data gathering process, I did preliminary analysis which was followed by a detailed analysis after the data had been collected. As many extracts as possible were collected from original sources in order to keep participants' words in their original state. The information that emerged from interviews culminated into a questionnaire, document analysis.

As stated earlier in Section 1.2.2, this research was motivated by a critical look at and analysis of grade 12 results in Biology for five consecutive years as well as through analyzing the Examiners' reports. Many learners obtained low symbols in Biology which prevented them from qualifying for admission to tertiary institutions. The Examiners' reports indicate the errors, the consistent as well as inconsistent usage of scientific language, difficulties experienced by learners and specific questions that were answered well and those that were not answered as well as expected. To determine some contributing factors, the linkage between assumptions and real findings are presented in this chapter.

The data is presented in the following order: teachers' profiles, data from my pilot study, document analysis, feedback from questionnaires, and the lesson observations. This chapter begins by presenting the participating teachers' profiles, to contextualize the gathered data. Findings from the emerged themes are presented in the order they emerged in response to research questions (Section 3.3.2).

4.2 Participating teachers' profile and the coding

Two participant teachers from two schools were involved in this study. Both schools are government schools, one is situated in a suburban area and the other about 8 kilometres (8 Km) outside the town in Kunene of Namibia. The teachers were selected on the basis of purposive sampling to gain insights from experienced teachers and especially to understand the challenges experienced, when mediated teaching of Biology in general and particularly with regard to the topic of respiration. For ethical reasons (Section 3.8), codes were assigned to both teachers and the schools as discussed in Section 3.8. The first school I visited is referred to as School 1 and coded as (S1) while the teacher in the same school was coded as Teacher 1 (T1). Likewise, the second school is referred to as School 2 and coded as (S2) and the teacher in that school was coded as Teacher 2 (T2). The Circuit was also given a pseudonym because coding alone would not protect the participants' identities seeing that there are only two Secondary schools in this circuit.

4.2.1 Teacher 1 (T1)

At the time of this study Teacher 1 worked in School 1 (S1) which was in a township and had no laboratory nor sufficient practical equipment and chemicals, but each learner had three different biology textbooks (see Section 4.5). The learners and the teacher spoke English but it was not a mother tongue to any of them. The teacher spoke Oshiwambo as her mother tongue and learners were from different ethnic language groups. Teacher 1 was an experienced teacher who had taught for 8 years and 2 months and specifically she taught Biology for 7 years and 7 months at the time of the study. First, she taught Grade 3 at Oniiwe (pseudonym) Primary School in 2002. In the same year she got an offer to teach Social Studies in Grade 5 at Olukonda (pseudonym) Primary School. She served as a relief teacher for 3 months in each Primary school. In 2003 she was admitted for further study at the University of Namibia where she completed her Bachelor Degree in Education specialized in Geography and Biology, Grades 11-12 levels.

In addition, T1 was a Bachelor honors graduate in Inclusive Education from University of South Africa (UNISA). At the time of the study, she was a Biology marker at the National Level in Namibia. She taught Biology since 2007 on a contract basis at Wellness (pseudonym) High School in Windhoek. In 2008 she was permanently appointed at S1 where this study was undertaken. Teacher 1 taught Biology Grades 11-12 and Life sciences in Grade 10. She was a part time tutor for Life science and Biology for Namibia College of Open Learning (Namcol) since 2008.

4.2.2 Teacher 2 (T2)

Teacher 2 is based at School 2 situated about 8 km outside the town with neither laboratory nor any equipment for practical activities in Biology. She joined this school in May 2011. Each learner had three prescribed textbooks identified as: Namcol Biology Modules, Excellent Biology and General Certificate of Secondary Education (GCSE) Biology textbook by D. G. Mackean. Notably, the Learners/textbook ratio was quite impressive as observed that each learner has all these three text books.

Teacher 2 speaks Oshiwambo as her mother tongue and learners are from different ethnic language groups. Both learners and teachers spoke English as a Second Language (ESL).

Teacher 2 held a 4 year Bachelor degree in Education specialized in Biology and Physical Education grades 11-12. She was a graduate from the University of Namibia. Teacher 2 was employed at Oshaakondwa (pseudonym) Combined School as a relief teacher, where she taught Physical Science and Biology Grades 11 for 3 months only. The same year she was permanently appointed at School 2 where this study was conducted. She had 3 years and 8 months teaching experience of Biology, at the time this research was conducted. She also taught other promotional subjects such as Development Studies, Geography and Life Science although she only specialized in Biology.

These two profiles were used to analyse the PCK of the teacher and the challenges faced in mediating learning.

4.3 Data from pilot study

Piloting was crucial as it gave an opportunity to check for the clarity of interview questions which culminated into a questionnaire. Similarly, ideas shared on semi-structured interview questions gave some insights into the appropriateness of the approaches used. Consultation with my fellow Masters' students and piloted data tools enabled me to reflect on the type of questions I framed to answer the research questions.

A Biology teacher from a Secondary School in Omusati region was used in the pilot study. She indicated how she uses learners' prior everyday knowledge and emphasized the need to use it. Based on how she introduces the topic, she said: "*I elicit learners' existing knowledge".* She claimed to start with a quiz and the activities focused on definition, and equations from Grade 9. On the questions about her views and experiences, she said that*: "learners' prior knowledge help to set the standard of teaching and the methodology to use to address new concepts",* thus addressed research question 1 of this study. She said she introduced learners to bread making seeing that many learners may have first-hand experience and they therefore would be able to relate that example to what they did in household chores, this being a response to research question 2. Then most of learners' answers would be answered by the explanations which the content also aimed to address. She said that in order to help learners make sense of the topic concerned, "*I conduct practical activities where learners are given instructions to follow and carry out the experiment on their own. From the experiment learners can test the presence of* *carbon dioxide using limewater or hydrogen carbonate solution",* which was a response to research question in Phase two.

On the teaching strategies she said: "*I use questions and answers, give class activities and topic tests derived from previous examination question papers and advanced Biology books to maintain standards and expectations of teaching and learning. These questions are drawn from the respiration topic and link content to everyday life experiences* (ibid)" as required by the Natural Science Policy discussed in Section 4.5.7 and responding to research question 2 of this study as also discussed in Section 5.3.4. She reported that, "*some learners have basic knowledge of respiration from previous grades as a result; I have to bring in the basic knowledge from previous grade. At the same time, learners who already have prior knowledge will not have interest in the lesson* (ibid)". She added that, "*most learners do not have skills to balance the equations and more time is spent to teach them on how to balance the equations".*

Furthermore she wrote: "*some learners remain convinced by other teachers and they would make reference of what the previous teachers said making teaching and introduction of advanced new knowledge challenging*". In order to address the challenge above, she said: "*during teaching I pay attention to basics and the same time, I keep learners with prior knowledge busy with activities".* She narrated that, "*more work is given to learners who do not have prior knowledge".* In addition, she claimed to consult her colleagues who teach Chemistry to address the problem of equations. This redresses the issue of inadequate mathematical skills and research question 2 of this study and this is also discussed in Section 5.3.5.

The data from the pilot were useful as it give insights and responses to the research questions in this study as discussed in Sections 5.3.1, 5.3.2 and 5.3.3. Other teachers might also learn from the data gained through piloting (Section 4.3).

The following subsection presents the data that emerged from Phase One.

PHASE One

4.4 Document analysis

Documents accessed included The Biology Syllabus, prescribed Textbooks, Examiners' reports, lesson plans, learners' note books as well as class activities/exercise books. Three prescribed Biology text books for Namibia Secondary School Certificate Ordinal/Higher levels, Grades 11-12 were analyzed, namely the GSCE Biology (3rd Ed.) by D.J. Mackean, Biology Excellent book by T. Chauke and Biology module 2 by N. Kadhila. These were the textbooks used in both schools. I analyzed documents with the intention of gathering rich thick data for the research which could both provide insight to my research questions as discussed in (Section 35.1) and help in data validation (Section 3.7). In addition, I analysed the above documents to get insights on how the topic respiration is presented and the suggested activities including practicals.

The next section gives detailed information on how the respiration topic is presented and assessed in these documents.

4.4.1 Biology Syllabus Grades 11-12

The syllabus is sequentially divided and subdivided into themes, indicating each topic, its learning objectives and basic competencies required. The focus of this study was Theme 8: Respiration, which was divided into 8.1 Aerobic respiration and 8.2 Anaerobic respiration.

From the analysis of the Biology syllabus, it was found that the basic competencies were clear and systematically presented. However, the relevancy of learning this topic was not given, which would have helped to guide teachers as they present and explain to learners. Naturally, if learners took note of the relevancy of the topic to their everyday life and their future careers then they would be keen to have skills in brewing and bread making for their personal social and economic empowerment. That may transpire if the sense of having this kind of knowledge is foregrounded. That could help to motivate learners to learn the topic since they would not only be learning it for examination purposes but also for their knowledge base for capacity building as addressed by research question 4. If the syllabus lacks an outline of relevance, only exceptional creative expert teachers might think of that and try to establish links of theory to practice.

Table 4.1 Presents the basic competencies for the topic respiration as indicated in the syllabus for Grade 11-12 Biology ordinary level

THEME/TOPICS	LEARNING OBJECTIVES: Learners will:	BASIC COMPETENCIES: Learners should be able to:

8. Respiration	Realize that cell respiration is needed for the release of energy in all living organisms.	Define respiration as the release of energy from food substances in all living cells.
8.1Aerobic respiration	Know that aerobic respiration yields a lot of energy in the presence of oxygen**.**	1. Define aerobic respiration as the release of a relatively large amount of energy from the breakdown of glucose, by combining it with oxygen. 2. State the balanced equation for aerobic respiration (using words and symbols). 3. Name and describe the uses of energy in the body of humans.
8.2Anaerobic respiration	Know that anaerobic respiration yields relatively small amounts of energy in the absence of oxygen.	1. Define anaerobic respiration as the release of a relatively small amount of energy, by the breakdown of glucose, without oxygen. 2. State the balanced equation for anaerobic respiration in muscles and yeast (using words and symbols). 3. Describe the role of anaerobic respiration in brewing and bread-making. 4. Describe the production of lactic acid in muscles during exercise. 5. Compare aerobic respiration and anaerobic respiration in terms of relative amounts of energy released.

Table 4.2 Suggested practical activities on respiration as described in the Grade 11-12 Biology syllabus

Practical suggested	1. Investigate the differences in carbon dioxide concentration in inspired and expired air, using limewater and a hydro carbonate indicator solution. 2. Investigate the effects of respiration and photosynthesis on the carbon dioxide concentration of air and water, using hydrogen carbonate indicator solution.
	3. Investigate the effect of the presence of oxygen on the germination of seeds.

	4. Investigate the production of carbon dioxide by yeast in anaerobic conditions.
	5. Investigate the effect of exercise on breathing rate and explain this in terms of the build-up and subsequent removal of lactate.

Adopted from Biology syllabus (Ministry of Education: NIED, 2010, p. 14)

The intention of the syllabus in listing these activities is that learners are assessed and expected to demonstrate practical skills and abilities in this subject and specifically this topic. Practical skills assessment consist of 20%, handling of information, application and solving problems constitute 30% and knowledge with understanding make up the remaining 50% (with restrictions of recall questions to not more than 25%). It was however encouraging and motivating that the syllabus has a glossary of terms used in the science question papers, and action verbs such as calculate, deduce, outline, discuss, sketch, measure, and determine (MoE: NIED, 2010, p. 34).

This glossary aimed to guide teachers to structure their questions and tasks for their learners during the year in preparation for the examinations. However, examiners' reports show that learners often had not mastered the expectations of these tasks in cases when the instructions were not well constructed, which can be a challenge and constituted responses to research question 3.

4.4.2 Textbook 1: General Certificate for Secondary Education (GCSE) Biology (3rd edition)

This was a prescribed textbook for Secondary schools in Namibia. It included the topic on respiration. Its content was found to be relevant for the Senior Secondary level, which includes material for Grades both grades 11 and 12. This book had also a glossary with some key words and abbreviations. It was motivating to find that this book has suggested practical activities and illustrations which were fully explained at every stage. That would capture attention and facilitate understanding of what is expected and what needs to be learned (see Figure 4.1). The illustrations and sequencing of steps required in carrying out practical activities help teachers and learners to manipulate and handle apparatus. In addition, it helps learners to explore activities on their own.

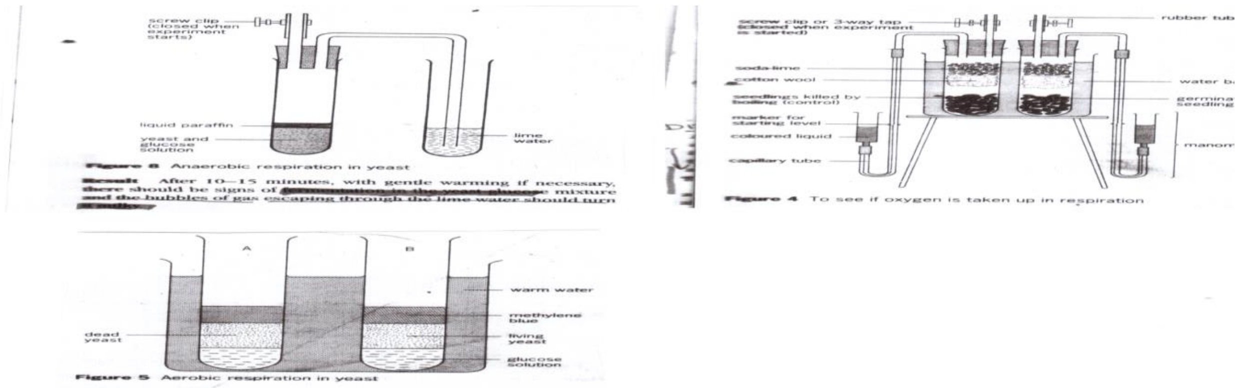


Figure 4.1 Illustrations of practical apparatus needed on respiration

Accompanying text explained how the apparatus could be assembled, the steps/procedures to be followed, control in the practical and the expected results for a successful practical. Explanations were also given for each result, thus addressing the research question 3, also discussed in section 5.3.

4.4.3 Textbook 2: Biology module 2, Grades 11-12

This module textbook for the New Namibian Biology syllabus was prepared by the Namibia College of Open Learning (NAMCOL). It provided a few glossary terms and hints in the margin. For example, after the chemical equation of respiration ($C_6H_{12}O_6 \rightarrow 6CO_2 + 6H_2O$) it noted: *there is the same number of carbon, hydrogen and oxygen atoms on each side of the arrow.* The suggested practical experiments were simplified, making it easy for learners to carry out practicals on their own with little guidance from their teachers. Furthermore the textbook contained model classroom activities and sample examination questions. This format seems to provide a good opportunity for learners and also the teachers to understand the concepts and mediation processes.

Another feature of this textbook is that in providing examples of respiration in addition to those that might occur in examinations, it also included examples from a typical child's home experience, such as 'bread making' and 'beer making' processes, both as chemical and biological processes. While not using the language of IK these are clearly both indigenous practices in most cultures.

The topic of respiration was organized into this order: Definition of respiration, aerobic respiration, and anaerobic respiration; words and symbol equation for aerobic and anaerobic respiration in muscles (human tissues) and yeast (fermentation); use of energy in the body, the role of anaerobic respiration in brewing and bread-making, the production of lactic acid in muscles during exercise, comparing of aerobic and anaerobic respiration in terms of energy released. In addition, it provided a summary at the end of each topic. It also contained a list of

When you have studied this unit, you should be able to:

- define respiration as the release of energy from food substances in all living cells
- define the term aerobic respiration
- state the equation for aerobic respiration in words or symbols describe the main uses of energy in the body
- define anaerobic respiration
- state the equation for anaerobic respiration in muscles and yeast using either words or symbols
- describe the role of anaerobic respiration in brewing and bread-making
- describe the production of lactic acid in muscles during exercise

suggested practical activities (see Figure 4.2).

Figure 4.2 Depicts the basic competencies that learners are expected to know after studying the topic which show direction for exploratory learning

The content and the sequence of information agreed with the basic competencies in the syllabus (Figure 4.2) and were systematically arranged to create a smooth cross over from simple to complex content in this textbook too, shortly after the introduction. My analysis of this book led me to applaud it as user-friendly to both teachers and learners. It enabled learners to carry out experiments on their own and read ahead before the class activities.

When analyzed this book, I noticed that it did not explain the fermentation process in detail as that might be a new word to some learners, though it plays a major role in brewing, seed germination and bread-making. This limitation encourages me to urge teachers not to be limited to textbooks and laboratory equipment but to dig deeper and go outside the box to explore different methods to help learners comprehend the concepts underlying respiration.

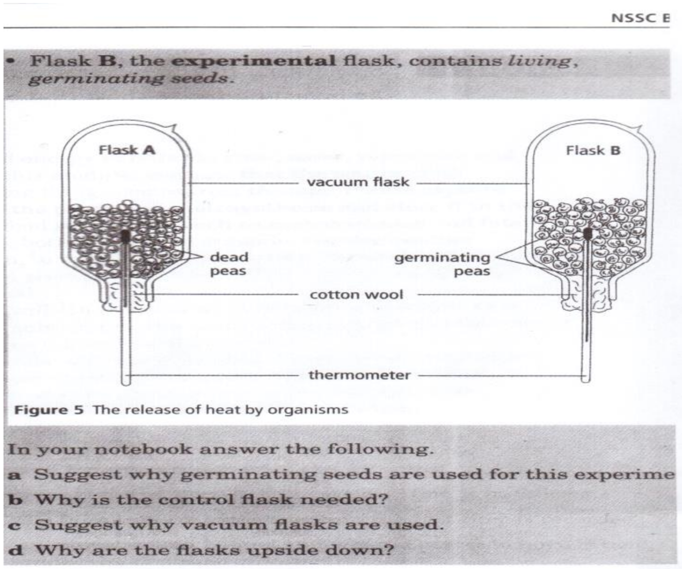


Figure 4.3 Shows apparatus for practical activity for germinating seeds

The illustration above shows the assembling of apparatus and questions to test and develop learners' conceptual knowledge during or after the practical activity. Novice teachers may find this activity user-friendly because model answers are provided (in the answers to activity book) for them to compare with their results after conducting practical activities.

ACTIVITY 5

Spend about 5 minutes doing this activity.

Put your arm straight up over your head. Clench and unclench your hand as if making a fist. Do this until you cannot continue. In your notebook, write down why you had to stop!

ACTIVITY 6

Spend about 5 minutes on this activity.

Complete the table below by writing in the spaces.

Aerobic respiration	Anaerobic respiration
1 A lot of energy is released.	1
2	2 Oxygen is not used.
3 CO_2 is released.	3
4	4 Takes place in some unicellular plants and in muscles for a limited time.

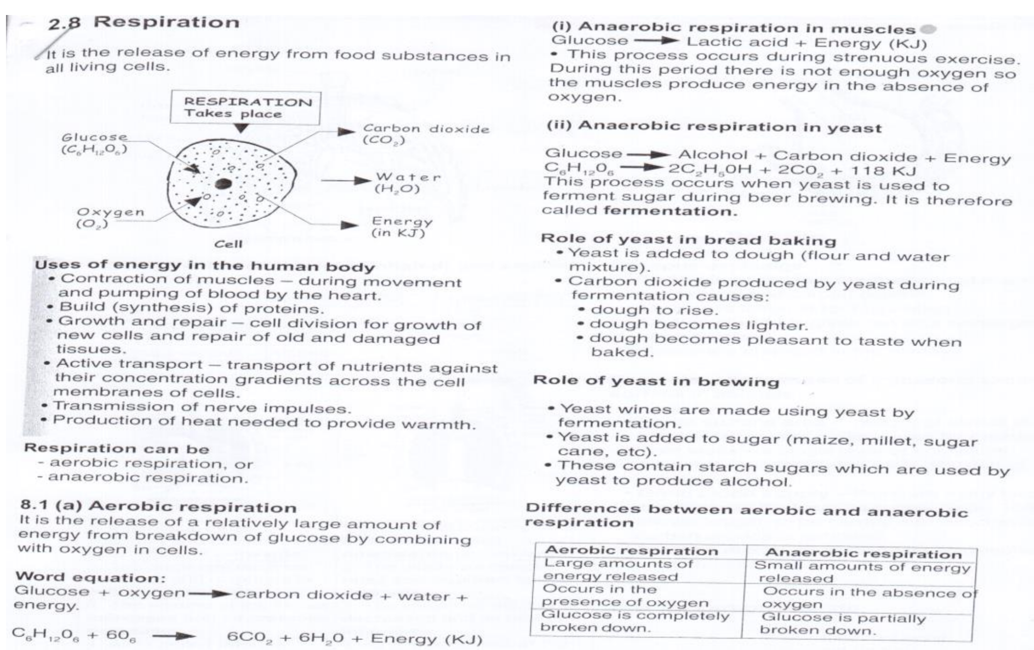
Figure 4.4 Shows samples of activities to promote active interaction and dialogue on respiration extracted from textbook 2

This textbook includes a number of activities which could assist both teachers and learners to assess their strength and weakness about various areas of respiration.

4.4.4 Textbook 3: Excellent Biology book

This textbook was well simplified and summarized. It had suggested activities but lacked sufficient practicals activities for assessment. It also had end of topic examination sample questions in multiple choice and structured questions. The textbook provided answers numbered according to the questions at the end of the book. However, I noticed that some explanation details were missing.

Although some of these practical's were suggested in the syllabus and their relevancy was discussed and recommended by several studies (MoE, 2010; Maselwa & Ngcoza, 2003; Hart, 2003; Millar, 2004; Hattingh, et al., 2007; Roberts, 2004) there was no guidance based on practical work on this topic.



2.8 Respiration

It is the release of energy from food substances in all living cells.

Uses of energy in the human body
- Contraction of muscles – during movement and pumping of blood by the heart.
- Build (synthesis) of proteins.
- Growth and repair – cell division for growth of new cells and repair of old and damaged tissues.
- Active transport – transport of nutrients against their concentration gradients across the cell membranes of cells.
- Transmission of nerve impulses.
- Production of heat needed to provide warmth.

Respiration can be
- aerobic respiration, or
- anaerobic respiration.

8.1 (a) Aerobic respiration

It is the release of a relatively large amount of energy from breakdown of glucose by combining with oxygen in cells.

Word equation:

Glucose + oxygen → carbon dioxide + water + energy.

$C_6H_{12}O_6 + 6O_6 \rightarrow 6CO_2 + 6H_2O$ + Energy (KJ)

(i) Anaerobic respiration in muscles

Glucose → Lactic acid + Energy (KJ)
- This process occurs during strenuous exercise. During this period there is not enough oxygen so the muscles produce energy in the absence of oxygen.

(ii) Anaerobic respiration in yeast

Glucose → Alcohol + Carbon dioxide + Energy

$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$ + 118 KJ

This process occurs when yeast is used to ferment sugar during beer brewing. It is therefore called **fermentation.**

Role of yeast in bread baking
- Yeast is added to dough (flour and water mixture).
- Carbon dioxide produced by yeast during fermentation causes:
  - dough to rise.
  - dough becomes lighter.
  - dough becomes pleasant to taste when baked.

Role of yeast in brewing
- Yeast wines are made using yeast by fermentation.
- Yeast is added to sugar (maize, millet, sugar cane, etc).
- These contain starch sugars which are used by yeast to produce alcohol.

Differences between aerobic and anaerobic respiration

Aerobic respiration	Anaerobic respiration
Large amounts of energy released	Small amounts of energy released
Occurs in the presence of oxygen	Occurs in the absence of oxygen
Glucose is completely broken down.	Glucose is partially broken down.

Figure 4.5 Shows how the topic respiration and its' concepts is presented in the Excellent Biology Book

This extract from the textbook above, started with the definition of the key concept of respiration followed by subtopics: aerobic and anaerobic respiration as presented in the syllabus. The topic started with the uses of energy in the human body as released from respiration processes. That treatment might arouse curiosity among learners to learn how respiration is important to their bodies.

In contrast, it was disappointing to see that the equation for respiration was not represented by a double reaction which would depict that the equation is reversible, showing a relationship to that of photosynthesis. Surprisingly, the equation from this extract was not balanced; there being an unequal number of oxygen atoms on the two sides of the equation (Section 4.5.3) (aerobic respiration equation in the extract above). An outcome of this deficiency was that when T2S2 presented equations for anaerobic respiration using this text book, she did not provide the symbol equations that take place in muscles, only managing to give that in words. The teacher and her learners did not check that against their other references. A learner asked if lactic acid does not have a chemical formula, and T2S2 confidently replied "*it does not have*" (see Lesson Observation 2 of S2) which would be confusing to learners if they discover that it does, and they may not even bother to find out. Consequently, learners may carry along their misconceptions and may not be able to attend to any of that question in the examination and that would affect their academic performance.

Furthermore, the reactants and the products' states were not indicated which would have been a good way for learners to relate what they learn in Physical Science to that of Biology. Numerous other errors were evident in this textbook; thus teachers are cautioned to carefully guide learners by using different learning and teaching support materials (LTSMs).

4.4.5 Examiners' reports

I analyzed the Examiners' reports for 2008-2013 and identified key issues. It appeared that teachers used everyday language to interact and explain concepts regarded as difficult, in order to make them easier to understand although such an approach is contradictory to scientific practice (Biology included). Sometimes, the attempt to simplify the terms turns into dilution of a real meaning of a scientific term. For instance, Examiners' reports indicated that in one question in paper 2 Biology of 2013, learners were asked to mention *conditions* but instead they gave *factors*, which is a language problem. Furthermore, they reported that learners lacked mathematical skills needed in measurements and in calculations.

In another question specific to respiration, some learners did not know that cell respiration takes place in the mitochondria (as discussed in Section 1.2.2).

Additionally, learners were challenged by question 21 of the multiple choices of the same paper. Only 33.3% of candidates knew that the correct order for biological changes during a 100-metre race is muscular activity producing carbon dioxide, which causes an increase in the carbon dioxide concentration in the blood, which causes an increase in the breathing rate, which then results in increased availability of oxygen to the muscles. These examples provide evidence that this topic needs to be investigated to provide insights into the way forward to improve teaching and learning. This study aimed to find out how teachers mediate the topic in selected schools, addressing research question 1, 2 and gain insights into what challenges teachers are faced with (research question 3) for possible intervention (addressing research question 4).

4.4.6 Lesson Plans

Examining the policy and guidelines on lesson planning

Lesson planning and preparation need special attention and enough time for consideration within the teaching profession. The Ministry of Education has a clear policy on the matter of planning and preparation. Thorough and careful lesson planning and preparation helps a teacher to teach better because in enables the teacher to think carefully about what to do in class. The Ministry of Education English teachers' Guide for Grades 5-7 (National Institute for Educational Development (NIED), 2009), indicates that "if we have not planned lessons, we waste a lot of teaching and learning time in class" (p. 12). The confidence in teaching is lost and the teacher is unsure of what to do next and not all the activities/worksheets/instructions he/she want to use may be available, clear or ready when need to be used (ibid, 2009).

It is the responsibility of each teacher to write quality lesson plans and that means that any natural science teacher should, after looking at your lesson plan, be able to present it. The Policy further states that learning competencies should be clear; the activities should be aligned sequentially according to syllabus basic competencies and all the necessary teaching and learning materials should be organized beforehand (Ministry of Education, 2009). The following components must appear in the lesson plan: introduction, detailed content, assessment activities for the learners (written task), methods/approaches used, and consolidation.

4.4.6.1 Lesson plans for Teachers (T1 and T2)

Lesson plans for T1S1 were well detailed (Appendix 4A). However, this lesson did not indicate learners' assessment activities or homework on this topic as per the subject policy for Natural Science/Biology. Some of her lesson plans however indicated activities for learners and monitoring of learners' work. Lesson plans for T2S2 were not detailed (Appendices 4C & 5D), which indicated a lack of proper planning skills to include most of the activities that the teacher and learners would do.

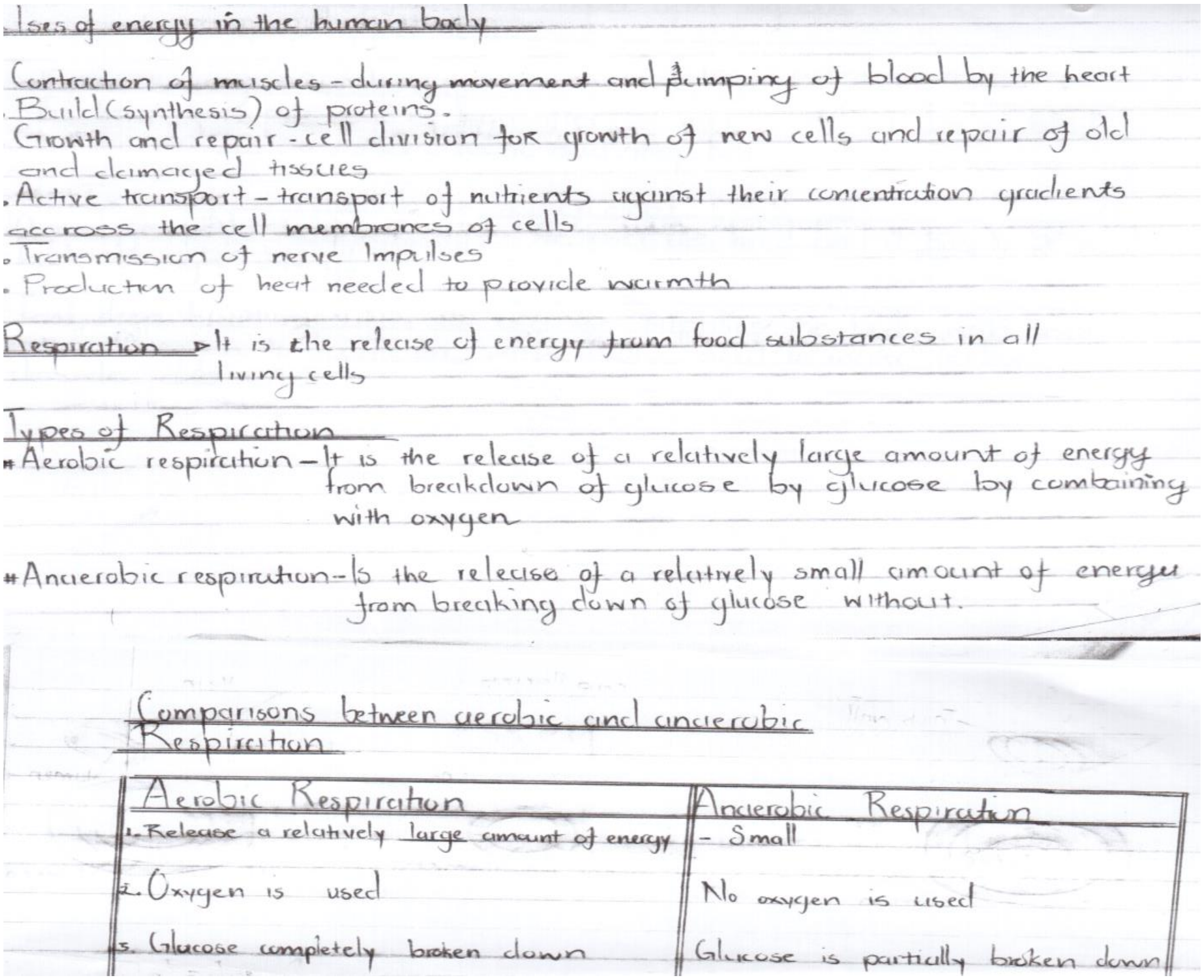
Lesson plans indicated the introduction, presentation and conclusion. Practical activities appeared in their lesson plans. It appears that teachers are facing serious challenges to conduct practical activities with their learners, due partly to limited resources at their disposal (Appendices 4A-D).

4.4.7 Learners' workbooks in S1 and S2

The National subject Policy of Natural science gave directives that learners should be given quality assessment activities based on what they are taught as discussed in Section 5.3.2. It further, stated that at least learners must be given an activity and a home work to do daily in science subjects, which includes Biology. The learners' workbooks were analyzed on the basis of this Policy guideline.

4.5.7.1 Learners' workbooks in School 1

Learners in School 1 were expected to buy note books. The teacher prepared notes for the learners. I asked her why she gave summaries to learners in her own words and she replied that *"learners may not exactly know what they need to know and they may end up copying everything written in the textbook*". Learners wrote their summaries as well as class activities in the back of the same book. It however appeared that learners wrote activities in other worksheets as seen in some of the answer scripts that learners attached on their summaries. Learners did not write concrete activities in this topic as this was a new topic to them at the time of data collection. I however managed to look at their summaries and a mastery test in previous topics. I found that questions asked were of high cognitive demand and encouraged critical thinking (Section 2.2). However through analyzing their daily activities, I discovered that learners' given work was quite limited in quantity, contradicting the Natural Science Policy guide regarding quantities of activities (Ministry of Education, 2009). That may limit learners' understanding as a huge once-per-term mastery test would usually be administered to them at the expense of other form of assessment.



Uses of energy in the human body

Contraction of muscles - during movement and pumping of blood by the heart
. Build (synthesis) of proteins.
Growth and repair - cell division for growth of new cells and repair of old and damaged tissues
. Active transport - transport of nutrients against their concentration gradients accross the cell membranes of cells
. Transmission of nerve Impulses
. Production of heat needed to provide warmth

Respiration ▸ It is the release of energy from food substances in all living cells

Types of Respiration
Aerobic respiration - It is the release of a relatively large amount of energy from breakdown of glucose by glucose by combaining with oxygen

Anaerobic respiration - Is the release of a relatively small amount of energy from breaking down of glucose without.

Comparisons between aerobic and anaerobic Respiration

Aerobic Respiration	Anaerobic Respiration
1. Release a relatively large amount of energy	- Small
2. Oxygen is used	No oxygen is used
3. Glucose completely broken down	Glucose is partially broken down

Figure 4.6. Shows a sample of a learner's summary on concepts discussed in School 1

During discussion with Teacher 1, it seemed she did not have sufficient time to check the learners' books for the correctness of summaries and whether all of them did write summaries, as there is no sign for monitoring. I also noticed that a very few learners' activities given had not been marked.

Therefore, teachers need to motivate and nurture positive attitudes toward science by exemplary teaching practices, and this may help learners to develop positive attitude toward science. This can be achieved through giving feedback to learners. For instance, if homework is done by learners but not consistently monitored, then it may not serve the intended purpose as observed in School 1 and this was one of the challenges observed that may hamper learning progress (corresponding to research question 3).

4.5.7.2 Learners' workbooks in School 2

Learners in S2 adopted a similar approach to S1 of buying note books for use as work books. Learners in S2 prepared their own summaries and took a few notes when the teacher explained concepts on the board. In our discussion with T2 as to why she preferred learners to prepare their own summaries, she had the following to say: "*I don't give summaries because learners end up only paying attention to summaries but they will not use other books, and that will limit their exploratory skills and learning abilities*". I asked her on the measure put in place since some of the books contained errors; she said '*errors in textbooks are clarified in the lesson presentation',* one of the response to research question 3.

I could not see learners' activity (an explanation given to the teachers was that they did not write much activity) but I managed to see their mastery test on a previous chapter which showed high demand of knowledge with understanding. A variety of questions were given including some with knowledge application as recommended in the curriculum of Ministry of Education (Section 2.2).

It seemed to me to be demotivating to give less daily assessment but at the end of the term to give learners a huge mastery test. There was no indication that learners' books were monitored by the school management or the teacher to see to it that learners fully carry out their responsibility for their own learning. Learners who did not have high self-efficacy would lose focus as there were no proper directions imposed on their progress. Concepts consolidations were done orally in S2 which did not foster conceptual writing skills (Appendix 4B: LPlan T2).

Analysis of the learners' work books revealed challenges (research question 3) faced by teachers in carrying out their duties as stipulated in the Natural science policy discussed in Section 4.5.7. This study further found out that learners' writing skills were undermined compared to speaking as teachers were focusing more on oral questions and responses than on written work. Thus, there is a need to support teachers by addressing the research question of Phase two.

4.5 Semi-structured interview questions culminated into a form of a questionnaire

To get a sense of Grade 11 Biology teachers' views and experiences of mediating learning of respiration I administered interview questions culminated into a questionnaire. I initially planned to conduct interviews with participants but due to their busy schedule, they preferred to complete their answers in their spare time. The objective for the interviews was to find out teachers' experiences when teaching respiration and to enable probing for clarity. A questionnaire was adopted to respect participants' choices as discussed in Section 3.8. I did follow up questions Teacher 1 face-to-face and with Teacher 2 telephonically.

In addition to the aim of finding out teachers' views and experiences in teaching respiration, this technique was used to triangulate my data. The interview responses addressed the research questions in section 4.1 as insights on teachers' views and experiences were generated. Teachers were able to point out difficulties they faced as required by research question 3, to help determine how they could be supported (addressing research question 4). The data generated were then used to look critically at how the research would shape the lessons learned (discussed in Section 5.3.5) for future curriculum development and implementation to achieve intended goals as discussed in Section 5.3.4.

4.5.1 Questionnaire responses from T1 (Q-T1)

During the appointment for the interview, I took T1 through the questions and she asked questions for clarity. I explained to her and she was prepared to answer as expected but later she raised a concern of time and said she would not be able to complete the responses to the interview questions. I asked whether I should go back to structure the questions into a questionnaire form but she feared not being available the following day or so. Thus, the interview questions were culminated into a questionnaire.

Teacher 1 made use of learners' prior everyday knowledge as observed (Appendix 3B: Q-T1). When asked how she introduced this topic, in her own words she wrote: "*In my teaching of this topic respiration, I always integrate it with respiratory system chapter whereby I refer learners* *to organs such as lungs that supply oxygen to cells for respiration*". On the question about her views and experience with regard to prior everyday knowledge on respiration, she indicated that: "*Learners who have prior knowledge tend to understand the lesson far better than those who do not have any ideas"*. She added "*those with prior knowledge live to participate freely than their peers"*. When asked how she made use of learners' everyday life experiences she had the following to say "*I always ask learners to think how they end up walking from home to classes, what or where they got energy to move around or carry out various activities, hence learners should be aware that the energy they use is obtained from respiration when glucose is broken down in cells*". Based on lesson observed from T1, this did not transpire apart from being written down in the questionnaire (Appendix 5B: LO2T1).

In her response to the question on ways she helped learners to make sense of the concerned topic she answered that "*By giving and demonstrating simple example which is very well known by learners such as the similarities between respiration and burning and that the only difference is that no flames in respiration but both require fuel and oxygen"*. Additionally, she said *"both releases energy and waste products"* (Appendix: 3C). On the question of teaching strategies she used for learners to understand concepts underlying respiration, she wrote "*I group learners in groups of four, and each group will get a task to tackle and report back, therefore, I have to work hand in hand with each group, give assistance where necessary and then provide feedback to the entire class*". Based on my observation, T1 did divide learners into groups preferred by learners. I also observed that though learners were seated in groups, they were not tackling activities based on collaborative learning, rather they worked individually (Appendix 5A: LO1T1 and Appendix 5B: LO2T1).

Teacher 1 narrated that "*lack of advanced model or posters portraying the real pictures and parts of organs and tissues involving respiration real objects to demonstrate to learners what they have learnt in theory*" are some of the challenges learners face. In an attempt to address some of these challenges she wrote that "*I normally try to search and read more various books and google on the internet to enrich myself with the required knowledge towards the topic. She went on to say "I also contact other colleagues who might understand the topic far better than me*". This did not reflect accurately in her lessons, as some questions asked by learners challenged her subject matter knowledge. For example, in the second lesson observed she displayed poor understanding on concept of gluton, as asked by one of the learners (Appendix 5B: LO2T1, line 68-71).

A face to face informal discussion was conducted as a follow up to the questionnaire. Teacher 2 was asked on other ways used to scaffold learners and by giving examples, she emphasized the need for practical activities as these help learners to practice and experience how to manipulate equipment. But she agreed to the suggestion that natural available materials can be obtained from the environment and that the knowledge of indigenous people from the community can be accessed.

4.5.2 Questionnaire Responses T2 (Q-T2)

I explained to T2 the questions on the interview schedule before she answered. This interview questions were later culminated into a questionnaire as T2 preferred to give responses in a written form. The first question was on the way the teacher introduced the lesson. In her own words she said: "*I ask learners on where do we get our energy from, what is the formula for photosynthesis and why do we need carbohydrates*". However, compared to the lesson observation (LO1T2), these questions were not reflected in her lessons. She used learners' prior knowledge and contextualized the lesson (as prescribed by the curriculum) by asking the following question: "*You learn about respiration in grade 9, who can still remember, why respiration is important for life"?* (Appendix 4C: Line 3).

Based on her views and experiences of using learners' prior knowledge when teaching she wrote: *"Learners can understand this topic better if they build on what they know".* This was reflected on her observed lessons as discussed above. She used learners' every day knowledge example, "*I ask learners to run at least 3 rounds as they will know that when they exercise they use up energy, they require oxygen and some can even get a feeling of anaerobic respiration".* On the question about the ways T2 used to help learners to make sense of the topic she said: "*I make sure they know the definition, the formula and why they need respiration by telling them an example of an athlete when they run that they breathe faster, or some faint due to lactic acid*". This was reflected during lesson observations as she kept on consolidating and repeating what learners need to know based on respiration and its concepts (Appendix 5D:, LO2T2: line 3-23 & line 40-53).

In response to the questions on teaching strategies used for conceptual understanding, T2 said "*I give questions for the learners to answer and then help them depending on their needs and make use of a learner centred method*". This was the proposed and preferred teaching approach by the curriculum (Ministry of Education, 2010). Teacher 2 used the LCE approach in her teaching and where she deemed more clarification to learners was needed; a traditional approach was adopted (Appendix 5C: LO1T2: 38-60 & 132-138) to help learners to understand the concepts much better.

4.6 Lesson observations

Observation was the last technique used to gather 'thick rich' data and evidence of the classroom reality in a social setting (Section 3.3.3). Observation was used in order to complement the data generated from the document analysis and questionnaires. In addition, only through observations would I be able to get insights on how teachers mediate learning on respiration. Observation was considered a strong tool which generated a true picture of what happens during mediation of learning of respiration.

I observed three lessons from Teacher 1, of which one was a double period and each lesson was video recorded. All the lessons in both schools (S1 and S2) lasted for 40 minutes which is the maximum time allocation for Secondary Phase. Teacher 2 managed to complete the topic within two periods, thus I could only secure two lessons for this topic. An observation schedule (see appendix7) was used as a guide for lessons observed. During lesson observation, I took some field notes while the teachers were presenting as my critical friend was able to video record the lessons for me. I was able to observe various teaching methods employed by teachers as they scaffolded learners to make sense of the topic and master concepts.

Observing teachers' mediating learning in this topic was an eye opener to me and I was able to realize the challenges they experienced in this topic (T2). Similarly, I saw how teachers dealt with some of these challenges. This is discussed in section 5.3.5. During reflection on the lesson given by T2 while watching the video together with her, she indicated her opinions of her strength and her weakness, as highlighted in section 5.3.3. She was positive and willing to improve more especially when I proposed the planning of practical lesson with her.

4.6.1. (a) Lesson observations 1 Teacher 1 (LO1T1)

Lesson 1: 40 minutes

This lesson was about respiration but the previous topic was about the circulatory system. The lesson began with a recap of the previous one. Thus the teacher started the discussion with the question "*We can summarize just to round up the previous lesson. What did we learn"?* (Appendix 5A, LO1T1: 40 minutes).

This start was to find out if learners could still recall what they had discussed the previous day. The teacher used the questions and answers method to determine the achievement of lesson objectives covered in that topic as indicated below.

T1: Alright people that is enough for now. Today, we are talking about respiration. As far as from grade 8 we have been talking about respiration. When you talk of respiration, is a chemical process. What is expected of you when we are talking about respiration? Mbasa (pseudonym)!
L5: We are expected to learn about aerobic and anaerobic respiration.
T1: In other words: types of respiration in living organisms. Is that all, Percy (pseudonym)?
L6: We are expected to know equations for aerobic and anaerobic respiration.
T1: Thank you!

The teacher introduced the new lesson by connecting it with learners' prior knowledge on respiration from grade 8. She attempted to ask questions that were in line with the basic competencies. However the question of "*What is expected of you when we are talking about respiration"* would appear ambiguous to learners who might have found it difficult to understand what the teacher expected. The teacher drew a mind map on the chalkboard to show what learners' were expecting to learn, and showing the relationships of concepts underlying respiration. If she could have also asked learners why respiration is essential for their life, this would have helped learners to link the topic to the real world. It appears that language is a problem as reported by the University of Namibia (2012). In this case the teacher struggled to construct questions that could be understood by all learners.

L9: Only takes place in living animals!
T1: Only where? Is that true? Before we go to Kathy (pseudonym) a learner who was rising up her hand for a chance; why only in living organism? Yes you have an idea but you suppose to say: Is only living organisms have living cells.
L11: Give the difference between breathing and respiration.
T1: So what?
L11: Breathing is also included in inhalation and exhalation. There is no relationship between breathing and respiration
T1: Why do you need to talk about breathing if there is not relationship? For respiration to take place, glucose and oxygen is needed.
L12: Because respiratory system also includes respiration.
T1: Yes, I got your point but for the fact that you are denying that there is no relationship between breathing and respiration, how it becomes like contradicting.

For respiration to take place glucose and oxygen is needed. Oxygen goes straight to the lungs. The definition of respiration is the release of energy from food substances in all living cells. That is how you need to know it, like it or not. Stick to the definition in the textbook.

The teacher-learner interaction above shows active involvement by both teacher and learners. Teacher 1 was asking higher cognitive question that encouraged learners to think critically and this can help to develop conceptual understanding. For example, when a learner referred to respiration taking place in living animals, the teacher asked why only in living organisms. This kind of higher order questions enhanced learners reasoning skills as discussed in Blooms' taxonomy. I noticed that some learners did not know the range of living organisms where respiration takes place, which includes plants as well as animals. The teacher did not notice that misconceptions. It would have helped if she had asked them to give examples of living organisms.

L11 was also confused to whether a relationship exists between respiration and breathing. Teacher 1 probed and explained for the learners to realize that respiration and breathing are related. I however felt that learners' content knowledge of this relationship could be insufficient because the explanation given was not sufficiently explicit. To my understanding, she should have rather told them to stick to the definition in the syllabus, which she had provided on the chalkboard.

Although the teacher consistently utilized Excellent textbook, the chalkboard was also used to consolidate what is discussed and to write the equations involved in respiration. Surprisingly, the teacher said: *"For respiration to take place glucose and oxygen is needed. Oxygen goes straight to the lungs"*. In my opinion, that statement was wrong because there are two forms of respiration: aerobic (in presence of oxygen) and anaerobic (in absence of oxygen). The content knowledge needed to be strengthened, and consistent use of concepts was required. When teachers are confused of what to teach, this detracts from what learners will gain (Appendix 5A: LO1T1, Line 49).

The following extract gives an indication of teacher-learner interaction:

T1: With anaerobic respiration, glucose is broken down partially or half way. The types of…we did, now the equations. Ok people, sorry before we move to equation, we need to ……….about the organelles. What are the organelles we need to know? What are the examples of these cells?

Lrns: (chorus) not sure.

L16: Nucleus.

T1: Yes, is one of them.

L17: Ribosomes.

L18: Mitochondria.

T1: In which organelle is respiration takes place?

Lrns: (chorus) Mitochondria!

Despite the evidence of interaction between the teacher and learners, the teacher tried to simplify the terms example, she said: "*during anaerobic respiration glucose is broken down partially or half way*". While this could be a way to make the concept simple however it could also create misconceptions in the mind of learners. It was important for the teacher to indicate clearly that the accepted scientific explanatory word is *partially* and also to write the catalyst for the reaction (yeast) (Appendix 5A, LO1T1: Line 96). Otherwise if just left that way, learners would adapt the word *halfway* in their examination which would be rejected by the marker as not in agreement with scientific language. Another feature noticed was the teachers' inconsistency of asking questions, for instance, she equated organelles with cells which might have caused confusion among learners. Teacher 1 went on to relate what is being learned in Biology to other subject as in the exchange below:

T1: Yeee? People find the meaning of arrow is not only in Biology is in every kind of reaction you need to know that the arrow mean….what does that supposed to tell you? Yeee?

Lrns: talking together softly.

T1: Yee?

L1: Maybe is it not the..?

T1: I do not know, I am asking do not ask me again. Form what?

Lrns: A product (few learners talking).

T1: Mmhhuuu, respiration or sunlight?

Lrns: Mmhhhh (when the teacher talks about something that they did not say).

T1: Alright people, what are the products?

Lrns: (chorus) Carbon dioxide!

T1: Carbon dioxide plus?

Lrns: (chorus) water!

T1: plus?

Lrns: (chorus) energy!

T1: Plus energy. Now what is very important here is now the chemical.

Lrns: (chorus while the teacher is writing on the board) $C_6H_{12}O_6 \rightarrow 6CO_2 + 6H_2O +$ *Energy*

T1: Alright, oxygen normally is found as a diatomic----because ….but somewhere somehow the equation is not balanced, atoms are not balanced. What are we supposed to do? Let us see how many carbon atoms?

The teachers' probing directed and encouraged learners to participate in the lesson. I noticed though, that the balancing of the equation was problematic to both the teacher and the learners. It took some time to get the equation well balanced (Appendix 5A: LO2T1). The teacher used the chalkboard extensively in this lesson and learners showed interest to learn as they paid close attention especially during the balancing of the equation. It was noticed that some learners' responses to questions were very short, which could be a sign of language difficulty or lack of confidence in their answers (Appendix 5A, LO2T1: line 78-88 & 130-134). As they were busy balancing the equation for respiration, learners' were contributing but did not understand this equation. They engaged in the conversation as follow:

T1: Put six where?
Lrns: Behind hydrogen (chorus)
T1: And now, we are not having six now but eight.
Lrns: Quiet.

A few learners could show understanding as they were giving their contributions on balancing the equation but many of them were confused and did not know what was going on.

4.6.1 (b) Lesson Observation 2 Teacher 1 (LO2T1)

Lesson 2 and 3 (double period): 80 minutes

In this lesson, the teacher started by making learners aware about the continuation of the previous lesson. Thereafter, she stated the focal point of the current period as shown below.

*T1**:** We continue with respiration, but now focusing on the role of anaerobic respiration in brewing and bread making. What did you learn yesterday?*

L1: About definition of respiration.

T1: mmhh, Ok. Alcohol is also needed in our body at least you need a glass of wine as long as you are not over doing it. Boys when taking three a lady can take only one due to their masculinity, otherwise… It is now breaking down this sugar in order to respire, mmhh once it respires always we know now, with every respiration there are substances produced, those are……

Lrns: Carbon dioxide (chorus).

Teacher 1 engaged learners in the lesson through explanation, which was a way of clarifying concepts to the learners. However, this might not have encouraged most of learners to be actively involved. They would have learnt more while including most of their senses such as seeing and touching, the use of expression such as 'tell me I forget', 'involve me I remember' should not be ignored as discussed in Section 5.3.3. Learners should be able to see and experience different scenarios that were discussed during lesson presentation. As a teacher myself, I feel that we must put more efforts into organizing and structuring lessons including the Learning Support Materials to accommodate a wide range of learners.

In the following conversation, a learner wanted to know whether yeast will have the same effect on her as in the dough, because it seemed, the learner wanted to explore and experiment to see what would be the consequences if she ate yeast. Probably this learner wanted to make sense of the effect of yeast by looking at different angles, which also responding to research question 4 of this study. For example,

L3: What happen if I eat yeast?

T1: If you happen to eat this yeast as you are saying bloating will come in. In most cases bloating will come with any type of food substance, some people when they eat for example, even some times is the pumpkin, depends to individual person. Some times after you eat the pumpkin you feel the tummy is going up. And then after a while…….

Lrns: Mmhhhh.

T1: After then you pump out air you feel like then better and better until is finished. It might be like that we don't see the tummy going burst. The tummy is made up of flexible muscles which can expand…Which can expand until the tummy can go forward, but not bursting. Alright *people, now we need to understand that are… the role of brewing and bread making and also these processes of respiration and main reasons of these is to breakdown sugar which is now present in the bread, dough of flour. ………..Alcohol was produced during fermentation it has to evaporate because of the high temperature and then once this happen, you don't have alcohol present in the bread, but with alcohol, fermentation alcohol will remain if there is no burning for alcohol to evaporate.*

Although the teacher tried to explain concepts, more teacher talk was apparent. A variety of methods could be incorporated in order to enforce conceptual development of a wide range of abilities. For instance, the word *fermentation* appeared to be a new word to most learners but it was not well explored. Learners' prior knowledge was not catered for at this point. I concluded that this teacher's Pedagogical Content Knowledge with regard to Indigenous Knowledge was limited and this is discussed in Section 5.3.1. It was essential for the teacher to ask learners about traditional brewing from their cultural background. Learner 4 asked the following questions'

L4: The yeast if react with sugar, now when you bake what happen to gluton?

T1: I don't know. What is gluton? Is it an enzyme or what? I thought you are talking about enzyme. I don't know you can go further.

L4: Is a protein….it produces an enzyme..then when the gluton…

T1: What is gluton? Is it a substance or a protein?

L4: Is a product, is a product, an end product of catalyzation of sugar.

T1: Yee, ok. A product of ……

L4: Catalization

T1: Now, I don't know. Is it a product or dough itself? No. it is on bread. It is a protein again. Mmmhhh and then you also need to remember that after exposing the enzyme to extreme hot temperature, what will happen? What will happen to the enzyme?

Lrns: (chorus) Denature!

L6: When you put a lot of yeast in the dough what will happen?

T1: A lot of what? Did I say put a lot?

L6: No mrs, I am saying if you put a lot of yeast?

T1: Why do you have to put a lot? Are you not conservative enough?

L6: I don't mean like that?

T1: If you have too much it will also increase the reaction but if is too less the reaction will go down.

L6: Since you bake the bread, if you put too much it will have that funny taste.

T1: Now, Now what is your conclusion? People you ask things that you have answers and experienced yourself. You suppose to tell me and you have also reasons behind because if you ask me things that you experimented, I did not do the experiment. You suppose to tell me that what you have done…….. Now every time you just ask, now what is your suggestion? Because you are the person who went in the field to do the experiment, it was not me, you know what you did...

The extract above indicated considerable teacher-learner interaction and that may promote thinking skills of learners as they focus and ask questions. A good balance between teacher and learner talk was evident. Learners were eager and keen to know more about different factors that can affect yeast activities. However, what was missing was the use of practicals activities for the learners to see the reality of what they were learning theoretically. On page 23-25 of the GCSE Biology 3rd edition textbook were provision of practical experiments to be done by teachers with their learners in this topic. Practical activities are also suggested in the syllabus (MoE, 2010) on page 14. Essentially, the National Policy Guide for Natural Science has made provision for teachers to be creative and innovative to produce their own teaching and learning aids applicable to their context. Unfortunately, this was not observed. Learning could happen more effectively if learners are engaged, involved and fully experience what they are learning. As indicated by the question: *Mrs*, *the yeast if reacts with sugar, now when you bake what happen to gluton?),* it shows that some learners are reading ahead of the teacher as shown by the following response of teacher 1. *I don't know. What is gluton? Is it an enzyme or what? I thought you are talking about enzyme. I don't know you can go further.* It seems the teacher did not understand what the learner was talking about. This is evidence that some learners were exploring further ahead. This should be a wakeup call to the teacher to have strong Prior Content Knowledge (PCK) about the subject they are presenting, to the benefit of everyone as also discussed in Section 5.3.1.

It appeared from the classroom observation that teacher 1 did not encourage learners to ask questions. In most cases only learners with strong self-efficacy asked questions while learners with low self-esteem might have lost the confidence to ask questions as some of her responses shut them off (see the conversation above and Appendix 5B: LO2T1). On the other hand the teacher asked questions of higher level to encourage them to reason and so become critical thinkers as shown in the extract below. This is in line with the curriculum (Section 2.2).

T1: Why are you saying, it seems not all the acohol have evaporated?

L6: Because of the smell and the taste.

T1: Who said that is alcohol? How do you know that that smell is for alcohol? May be from the yeast itself?

Lrns: Uuuhhh Mrs (chorus)!

The teacher consolidated each discussion on different concepts by highlighting the main ideas of the lesson by pointing out what learners need to know. Thereafter, the teacher read from a book that learners did not have access to. In that book, Teacher 1 read about traditional African beer. This information could be made more fascinating if it brought in practical activities to make the lesson more live (Appendix 5B: LO2T1: line 173-177).

On the same lesson, I observed that Teacher 1 gave home works but follow up and feedback was rarely done, which raised a question on how achievements on lesson objectives were determined. In my opinion, feedback motivates learners to do more and well on their homework but if feedback is insufficient or lacking, the effectiveness of the activities given is questionable and needs urgent attention. During the lesson observed, the teacher displayed some pedagogical knowledge; however, it needed to be strengthened through continuous professional development (CPD). During the lessons observed for T1, learners were not given a single opportunity to use the chalkboard.

4.6.2 (a) Lesson Observation 1 Teacher 2 (LO1T2)

This lesson was about the circulatory system and the pulse rate. Although this lesson was not a focus for my study it provided some points in relation to respiration and on how this teacher scaffolded learners to understand concepts. This lesson was also used to establish a relationship between me and the learners, to whom I was a new face. This enabled them to get used to my presence in their classroom, as discussed (Section 3.4).

The lesson started with testing achievement of previous lesson objectives through questions and answers.

T2*: How do we call the one that transport blood from body tissues to the heart?*
L6*: Vena cover.*
T2*: From the heart to the lungs?*
L4*: Pulmonary artery.*
T2*: That is what we discussed last time. So that build on what we are going to talk today. We are going to talk about the pulse, and later blood vessels. On page 48,….*

Teacher 2 connected the previous lesson with the topic they were focusing on for that day. She engaged learners into the discussions. Although more teacher talk was observed, of equal importance was the concept clarity in her explanation (Appendix 5D, LO2T2: line 105-127). It seemed that learners were not clear about some concepts presented, since they did not respond to some of the questions posed to them (see conversation immediately following). In most cases Teacher 2 did not give ample time to learners to answer the question she posed. Consequently, she answered her own questions as discussed in section 5.3.4.

T2*: Remember, this left ventricle, it pump blood with oxygen, and oxygen is the one that is used for which process?*
Lrns: *Respiration (chorus).*
T2: *"So when you are exercising you are using a lot of oxygen. Let say you are running when you are running, you are using your legs, so if in the legs the energy which is there is being reduced, so therefore your pulse rate will need to increase, to be able to supply blood with enough glucose plus oxygen (writing on the board) for you to be able to release enough energy. So that is the importance of increasing pulse rate during exercise. So it is not a bad thing as when you exercise you are also breathing and need to pump blood, with oxygen and breakdown*

glucose to release energy. That means you do not lose focus and you do not go for anaerobic respiration but we will talk about it tomorrow, but the good thing is that what you need to know that exercise will always increase your pulse. Why it is important? The main reason is that when you are exercising, you are……and that oxygen you need to be replaced, how can you replace it? You can only replace it if you pump blood with oxygen and glucose in those muscles that is one thing what you need to know. So turn on your book pick up the pulse rate, so the more vigorous is the exercise the fast the pulse. What does vigorous mean?

***Lrns**: No response.*

***T2**: Yeee?*

***L4**: More fast exercise!*

***T2**: Fast exercise or heavy exercise always causes the pulse rate to increase. The important is that in order to deliver oxygen and glucose to active muscles as quickly as possible to produce energy during respiration that's why.*

This lesson linked to the focus topic of respiration by the 'effect of exercise on pulse rate'. I now present lessons on respiration as observed.

4.6.2 (b) Lesson Observations 2 and 3 from Teacher 2 (LO2 & 3T2)

Lesson 2 and 3 (double period): 80 minutes

The lesson started with elicitation of learners' prior knowledge on respiration, in line with the curriculum (Section 2.2). At the very beginning of the lesson, Teacher 2 contextualized learners' content knowledge within its application as indicated below.

T2: You learn about respiration in grade 9, who can still remember, why respiration is important for life? Mpho (pseudonym)!

L1: For cells to obtain energy.

T2: Is it for cells to obtain energy? Another one?

L2: Another learner, answered: is for cells to release energy, to cool down plants.

This exchange showed that mediation of learning was taking place. The teacher also probed for learners to think of other reasons why respiration is important for life. The teacher did not bother much on the definition of the concept respiration as she assumed learners could still remember it. However, it might have been better if she had asked them to define respiration as well. Teacher 2 continued asking and probing learners to get deeper understanding on the type of organisms that respire. For example:

T2: So, do plants also respire or only animals?

L4: Animals. Another learner, others: both!
T2: Where does it take place exactly?
L5: In animals only.
T2: Who said only in animals? Why in animals only?
L5: Is it a question?
T2: Yes. The question is, if only animals do respire but not in plants, why you are saying so? you must have a reason for that.
L6: Living organisms

Teacher 2 asked higher cognitive level questions which could encourage learners to think beyond yes or no answers (Appendix 5D, LO2T2: line 12-23). Mediation of learning through questions and answers method was observed. The teacher evaluated learners' contribution supplemented their answers and clarified misconceptions. Some learners had thought only plants do respire and they did not think that plants are also living organisms. They had been considering only animals to be organisms, excluding plants. Thus, she said: "*You learnt about seven characteristics of living organisms and respiration is one of the characteristics. If you say only in animals, you exclude plants. So far we talk about nutrition, growth, and these are also characteristics of living organisms.* Though, these extracts demonstrate good scaffolding learners, she could perhaps have asked learners to give examples of living organisms: plants and animals that respire. This could have given a strong feedback as to whether learners understand the concept. In the same extract, the teacher PCK was seen to be powerful when she referred to learners' prior knowledge of the seven characteristics of living organisms as learnt in grade 9. This precise was worth emulating. Teacher 2 continued to explain and ask questions:

T2: Whenever respiration is taking place………….which food substance we need to understand? The food substance we are talking about is glucose, the main product of respiration. Which food substances or nutrients we are talking about from respiration? Hheee?

L8: Glucose or carbohydrate, fat or protein.

This exchange appeared to bring confusion to learners. Consequently, they may have had misconception around respiration. Glucose is not a main product of respiration but is rather a raw material for this process to take place. In addition, the food substances listed are not derived from respiration. To describe it more explicitly, respiration is a process whereby glucose is broken down in cells either aerobically (in the presence of oxygen) or anaerobically (in absence of oxygen) with the help of a catalyst (yeast). This confusion indicates that the teacher needs to plan thoroughly (Section 4.5.6), prepare notes and structure the lesson presentation in a way that is appealing to the learners. Despite the confusion on explanation of concepts, T2 confidently said: "*So before we continue, I want you to take note: energy can only be released from food substance or can only be converted from one form to another form, but energy can never be produced. Do not say respiration is a production of energy from food substances. Energy can never be produced, created but only converted from one form to another. The most important one is a definition that it's a release of energy from food substances. So that is a general definition of respiration you need to know that respiration takes place both in plants and animals, in your eye tissues, in your body, is your breast tissue. Simple because all of them have living cells and need to respire, so respiration takes place both in plants and animals.*

The teacher's PCK was powerful here, apart from the contradiction she had made because at the end, while consolidating the concepts learned she gave some clear points for example: *"Do not say respiration is a production of energy from food substances. Energy can never be produced, created but only converted from one form to another" (*Appendix 5D, LO2T2*:* line 39-52). The law of energy conversion was clearly elucidated here, and this is an acceptable scientific explanation as required by the syllabus (Section 2.2). Contextualization was also an indication that Teacher 2 was implementing the curriculum as she gave examples of organs where respiration can take place when she said: "*respiration takes place both in plants and animals, in your eye tissues, in your body, is your breast tissue".* Despite the above generalization, T2 could ask or alternatively inform learners about the site where respiration takes place, which is the mitochondrion (mitochondria: plural). However, the use of analogies, diagrams and conceptual change text might also have been used in consideration of learners' diversity in learning.

In this lesson, Teacher 2 referred learners to which pages they would find information she was presenting. Learners dictated the chemical formula for respiration while the teacher wrote on the chalkboard. The balancing of the equation was not a challenge to T2 though it might have been to the learners. However this equation did not show a reversible symbol which would have indicated the close relationship between respiration and photosynthesis (Appendix 4D, LO2T2: line 67-69).

Lesson 3

This lesson was a continuation of the previous lesson, which focused on the effects of exercise on respiration. However before she moved on with the next subtopic, T2 consolidated what they discussed, in her own words she said: "*Next we will talk about effects of exercise on respiration. I want you to know the differences between the two types of respiration. Aerobic respiration is the release of energy in presence of oxygen and anaerobic respiration is the release of energy in the absence of oxygen. They are two types of anaerobic respiration in words and symbols for both yeast and in muscles*" that were on the chalkboard as shown below.

$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2 + 118\ KJ$

Glucose +Oxygen $\longrightarrow$ *Alcohol + Carbon dioxide +Energy*

Glucose $\longrightarrow$ *lactic acid + carbon dioxide*

The teacher went on to introduce the effects of exercise but learners were still interested in discussing the previous concept of yeast and fermentation process. I observed that learners had continued asking questions about the two concepts. This suggests that the presentation should have covered more than two periods. Teacher 2 could have exposed learners to more examples, diagrams and videos on fermentation process including those from traditional perspectives of learners in her class. I also observed that T2 continuously answered questions posed by learners herself and did not provide much opportunity for other learners to contribute. This could diminish learners' thinking ability by leading them to wait to be fed with correct answers from the source provider (the teacher), which is opposed to the curriculum of the Ministry of Education.

L11: Mrs, sometimes you are making bread and put yeast but it did not rise. What happen?
T2: You did not put enough yeast. Otherwise you can use self-rising flour.
L11: Sometimes, it is just hard, it is not rising.
T2: Because anaerobic respiration did not take place because it .....read on page 69 in the module also, because CO_2 make the dough to rise and cake taste, make dough lighter.
L12: During anaerobic respiration.
T2: No,...
L7: Mrs, can you make dough to rise if you just add alcohol?
T2: No, is not alcohol that makes dough to rise but carbon dioxide. Carbon dioxide is what makes dough to rise.

In the above extract, there is an indication of teacher-learners interaction. Learners were asking more questions which showed that they were still interested in talking about yeast. It could have been more effective if they were introduced to visual and practical activities on respiration. Although the teacher used the chalkboard to illustrate and explain concepts and equations involved, experiments where there are variation on both the temperature and the amount of yeast could have been a good representation to explain some of the learners' questions. Some learners asked if alcohol can cause the dough to rise, because they did not understand why yeast was used and why it makes the dough to rise. When one of the learners asked whether anaerobic respiration in muscles does not have a chemical equation, T 2 had the following to say: "*No, this does not have a chemical formula*".

This brings the PCK of teacher under the spotlight. It showed that T2 did not read widely to have the necessary content knowledge of this equation, and as a consequence, learners had to take along misconceptions. Teachers need to read widely and have a good understanding of their subject area and gain confidence on what to present. Equally important, the teacher needs to prepare notes for the learners and through preparations; the obvious mistakes could be spotted and rectified or prevented from happening in the first place. With the strong balance of teacher-learner interaction, learners in this class had higher self-efficacy, as they kept asking questions that were aligned to the real world and their context as show below:

L13: Mrs, what will you advise to a runner?

T2: You just need to breathe as fast to make sure the body has enough oxygen to replace the lost. If you are fit blood is flowing well and oxygen lost will be replaced.

L14: What is ferment?

T2: Is a sour taste, the breakdown of glucose example in oshikundu, omaheu….

L13: Is Oshikundu not alcohol? Omaere also? Which mean we are eating rotten food?

T2: Not rotten so to say.

L13: It means every time we are eating bacteria.

T2: Not all bacteria, microorganisms are harmful.

L14: Also that thing people are making in Khorixas?

T2: It can last for how many days? For three days. The maheu also.

L8: Mrs, when you are running, is it lactic acid make you pain? Not tiredness?

T2: Yes, not tiredness, is lactic acid due to lack of sufficient oxygen in the body

The following question "*Mrs, what will you advise to a runner? It* was a good example that learners were interested in contextualization of the lesson to real world rather than theoretical explanations alone. It appears that the word '*fermentation*' was new to them, but the explanation given to the teacher was "is a sour taste, the breakdown of glucose example '*oshikundu', 'omaheu*'. In fact fermentation is not a sour taste, is a process involving the breaking down of organic materials (sugar/glucose) by microorganisms (yeast) to form alcohol (ethanol) and carbon dioxide gas in the absence of oxygen. To expand on this, fermentation reaction is catalyzed by an enzyme which is yeast. Yeast speeds up the reaction process producing the above products.

Learners' questions underlying respiration concepts were highly context bounded (Appendix 4D: LO2T2, line 157-169), which would be explored more through 'hands-on', practical works which could be infused with analogies and case studies. Multiple representations of teaching methods could allow more learners to be engaged and benefit from lessons rather than only a few learners. Teacher 2 indicated that she would use questioning method based on equations and help them when necessary but observation showed that learners were not given questions in relation to equations despite an example done on the chalkboard by the teacher.

In conclusion of my observation of lessons from T2, the following were noted: the teacher tried to use the chalkboard effectively as learning and teaching support material (LTSM). She also tried to involve the participation of as many learners as possible. Collaborative learning was not part of any lesson observed; instead learners were learning on their own throughout which might have had some negative impact on effective learning. This method favoured independent learners, while those who might have needed the assistance of others were totally ignored. In all lessons observed from T2, learners were neither given any class activity nor homework to support learning and understanding of discussed concepts. This contradicted her lesson plans (Appendix 5C), the Curriculum for Basic Education, the National Subject Policy for Natural Science and the syllabus (see Sections 2.2 and 4.5.1). Based on the evidence that emerged from the lesson observation, I concluded that T2 was still reluctant to embrace the new approach (LCE) as proposed by the Ministry of Education and which is in line with social constructivism which is the analysis framework of this study. As a result, learners would not have wide opportunities for exposure to scientific phenomena, nor be made wise enough to make critical and informed decisions on problems they may encounter in personal, national or global economic issues as required by the curriculum.

PHASE TWO

Based on the findings from lesson observation, I communicated the need for developing model lessons involving practical activities, in collaboration with the teachers. They appreciated the idea as further discussed in Section 5.3.3. These lessons were thought to develop learners' conceptual understanding as their multiple senses would be involved as the lessons would be more 'hands-on', 'words-on' as discussed in Section 2.4.1.5. At the same time, the model activities would serve as a teaching and learning support material and also as a means to increase learners' interest in the topic by incorporating relevancy to their real world context. Hence, the practical activities were more contextualized to learners' everyday lives. Examples of activities are provided at the end of the unit, which will hopefully be useful to the teachers, at the same time they are user-friendly to the learners, encouraging them to explore ahead as a means of self-assessment. Other examples of practical activities on respiration are illustrated (Appendices 6A & B) to help teachers to build on and go an extra mile of designing practical activities.

Some case studies were also included in the unit of work to help teachers to make learning of this topic fun. In discussion with Teacher 2, she reported that the practical activities designed might be useful. For example, in our discussion she said "*I wanted to make an activity on bread making*" and I asked her the type of water she could use during the bread making 'hands-on' activity. She replied that she would make use of hot water then I said "what would happen to enzymes' activity if hot water is used"? She said "*Ahaa, denatured, so I will set the activities with three different conditions, with cold water, lukewarm water and hot water to see the effect of these temperatures on enzymes' activity as well"*. The ideas generated above underscore the reasons for collaborative work to find solutions to educational problems that hinder the progress of effective teaching and learning.

The two teachers felt that the effort necessary for designing practical work together was relevant to my research question 4, as they struggled to handle laboratory equipment, the basis of research question 3. This outside laboratory activity could also enhance and stimulate learners' interest and better understanding of concepts, not only in respiration but also in other topics as testified by a teacher in the pilot study (Appendix 3A). In all the lessons observed, neither of the teachers gave learners the freedom to experiment with written language/work on the chalkboard as discussed further in Section 5.3.4. Both teachers had access to the internet, and they were close to the Teacher Resource Centre (TRC) with educational bouquet television but neither made reference to it. I advised them to make use of the Educational bouquet and to consult community members on where fermentation process was being used in the community. I sold that idea to them for improving teaching and in turn it was one of the responses to research questions 3 and 4 of my study.

4. 7 Emerging themes

Creswell (2013) advised that data analysis involves organizing the data, coding and organizing themes and interpreting the data into sense-making. To this effect I categorized data using the following emergent themes, to help me make sense of Grade 11 Biology teachers' views and experiences of mediation of learning of respiration during their lessons:

How teachers scaffold learners?

1. Pedagogical Content Knowledge (PCK) during scaffolding learners;
2. Use of prior every day knowledge;
3. The role of practical activities;
4. Teacher-learner interaction (mediation of learning);
5. Challenges experienced by teachers; and
6. How can teachers be supported to help learners make sense of respiration and its concepts?

4.8 Concluding remarks

This chapter presented data generated from the two research sites. The findings at this point indicate different levels of mediation of learning in respiration as evident from observations as presented in this chapter but discussed in detail later in Chapter 5 in the form of analytical statements. The emerged data were generated through questionnaires, lesson observation, document analysis and face-to-face formal and informal discussions with the two teachers which permitted possible suggestions for future use. During our discussions in Phase Two, teachers felt that community members could also be part of education to uplift and preserve the legacy of community culture as learners would come to appreciate the need for continuation of these activities.

In the next chapter, I analyse, interpret and discuss the findings by explaining them, based on the themes that emerged from the data gathered. The themes are interpreted and analyzed in terms of the research questions, taking into account the literature blended with the theoretical frameworks.

Chapter 5: Analysis, interpretation and discussion

Data analysis is the process of systematically searching and arranging the interview transcripts, field notes and other materials that you accumulate to enable you to come up with findings (Bogdan & Biklen, 2003, p. 147).

5.1 Introduction

This chapter deals with the analysis, interpretation and discussions of the case study which was conducted at two sites to trace and document how two Grade 11 Biology teachers mediate learning of respiration. This chapter analyses data gathered in the form of analytical statements in relation to my research questions.

The data being interpreted and discussed in this chapter were gathered using various data gathering techniques, namely, document analysis (curriculum, syllabus, textbooks, lesson plans and learners' work), interviews which culminated into being questionnaires (administered to the participant teachers) and observations from participants' classroom practices as discussed in Chapter 3. The discussion is further expanded with a narrative account and draws from literature and personal opinions. In assuring that discussions were related to themes that emerged during the data gathering process, analytical statements were developed to find answers to the following research questions:

1. What are the views and experiences of Grade 11 Biology teachers when mediating learning of respiration?
2. In what ways do Grade 11 Biology teachers scaffold learners to help them learn and make sense of the topic respiration?
3. What are some of the key challenges in the teaching and learning of respiration and its concepts?
4. How can Grade 11 Biology teachers be supported to help learners make sense of respiration and its concepts?

Furthermore, in this chapter I give a brief description on how the themes and analytic statements were developed in relation to my research questions. In addition, this chapter discusses the implication for emerged themes and further opportunities worth exploring to ensure that quality teaching and learning takes place effectively and that learners' performance is improved. This chapter ends with some concluding remarks.

5.2 How the themes were developed

During the data generation process, I engaged in the pre-analysis of data qualitatively as discussed in Section 3.6. This pre-analysis led to the derivation of the themes. That is, I began analyzing and interpreting data from a broad perspective. After that, specific categories of themes were addressed step by step to make sense of those meanings. Based on their study on qualitative data analysis, McMillan and Schumacher (2010) underscore that inductive data analysis is a process through which the qualitative researchers make meaning from the data, beginning with specific data and conclude with categories and patterns. After completing the process of verbatim transcriptions of the audio-recorded data from observation and data from questionnaires, at least six themes were identified. Denscombe (2007) describes construction of transcripts as a process of converting audio-recorded data into a format that facilitates data analysis. Coding the emergent themes enabled me to visualize and notice any single themes that emerged from the data. The colours used were green, purple, pink, yellow, red and orange to identify distinctive differences among the themes as shown in Table 5.1 below.

Table 5.1 Shows themes that emerged

Color	Theme
Green	Curriculum issues/ways of scaffolding learners (PCK)
Purple	Prior everyday knowledge
Pink	The use of practical activities
Yellow	Teacher-learner interaction (engagement)/teaching strategies
Red	Challenges faced (implications)
Orange	Possible gap for intervention to support Biology teachers

5.3: Analytic statements linked to this case study research

Table 5.2: Analytical statements that emerged from data and those that formed part of the theoretical framework

Data source	**Theme**	**Analytic statement**	**Research questions addressed**
Document analysis: Textbooks, syllabus, Natural Sciences policy	Curriculum issues	1.Pedagogical knowledge required by teachers to implement the curriculum	1 & 3
Questionnaire and observation	Supporting strategies used in teaching the topic concerned	2. Use of learners' prior knowledge to scaffold and help them make sense of concepts in respiration	1, 2 & 3
Observation	Everyday experiences, teacher-learner interaction, language and scientific language	3. Teaching strategies used to help learners develop concepts underlying respiration	2
Questionnaire, Observation and Learners' workbooks	Challenges faced in mediation of learning of concepts underlying respiration	4.Challenges faced by teachers when mediating the learning of concepts in respiration	3
Questionnaires, Observations and Learners' workbooks	Suggested alternatives to deal with the challenges faced in mediation of respiration and its concepts	5.Alternatives to deal with the challenges in mediation of concepts underlying respiration	3 & 4
Questionnaires, observation and stimulated recall interview	Reflection and teachers' views on the role of practical activities underlying respiration	6.Teachers' reflections on the role of practical activities	1, 2, 3 & 4

The six themes outlined in Table 5.1 emerged from data generated during the research process. The organization made it easier for me to visualize and specify the data source from which specific answers to individual research questions were derived. The following section discusses the findings under each analytical statement.

5.3.1 Analytical Statement 1:

Pedagogical knowledge required by teachers to implement the curriculum

The data for this theme were obtained from documents analysis, namely, the National Curriculum of Basic Education, the Biology syllabus where much attention was given to theme 1 which is respiration, the textbooks used by Biology teachers and the learners' workbooks (summaries and activities). In Chapter 2, I argued using the curriculum Policy guidelines in Section 2.2, the relevance of learning this topic in Section 2.2.1, the knowledge categories of teachers in Section 2.2.2, some identified misconceptions in cellular respiration in Section 2.3.1. Then these sections are interpreted and discussed simultaneously with reference to the pedagogical content knowledge required by teachers for successful teaching and learning in science as discussed in Sections 2.2.1 and 2.6.

To expand on the above and from the document analysis and observation during the research process, this study took note of consistencies and inconsistencies between the curriculum requirement and its implementation in the science classrooms' practice of the two teachers. For example, both teachers planned their lessons but their planning was not *per se* reflected in their lesson presentations as discussed in Chapter 4, Section 4.5.6 and shown in Appendices 5A-D of lesson observations. Although the two teachers had lesson plans, my analysis found that more effort was needed to systematically scaffold learners as expected by the syllabus.

Analysis of the lesson plans for T1 showed that more content was narratively articulated than for T2. Although more content output was written in her lesson plans and more was evident on implementing the lesson plans (Appendix 5B: LO2T1), she was also not familiar with the subject content matter presented by L4 as indicated in their conversation in the same appendix (line 270-275). Analysis of her lesson plans showed that practical activities did not form part of her

presentation. This revealed a mismatch between the curriculum requirements of lesson planning (Chapter 4, Section 4.5.6) and the implementation practices in her Biology classroom.
The lesson plans for T2 often reflected more outcomes than the lessons presented. For instance, in her lesson plan 2 she indicated that: *learners will do a practical activity on yeast in bread making and record their observation* but this was not observed in her lesson.

On the part of her lesson plan on consolidation, T2 wrote: "*Anaerobic - glucose + oxygen*", with no clear reference given on how these would be consolidated. To add weight to this, it was surprising to find in the reflection part of her lesson plan that T2 indicated that the *lesson objectives were achieved*, although observation revealed that the planned practical activities were not performed. I thus, realized that carrying out a research through documents may not always give a true impression without the support of observations. The observations enabled me to come up with suggestions, recommendations and conclusion.

As highlighted in the Biology syllabus (Ministry of Education, 2007, p. 14) the basic competencies in each topic are required to be mastered by the learners, hence these should be the focus for teaching and learning. Though the broad curriculum and the syllabus did not indicate how the science teachers should scaffold learners, it did give some directives and it is clearly stipulated the basic competencies to be achieved as highlighted in Chapter 4, Tables 4.2 and 4.3. The observations showed that both teachers diverged from the curriculum directive discussed in Section 2.2 which says: *Learners should be provided with well-designed studies of experimental and practical science, a worthwhile educational experience to acquire sufficient knowledge with understanding'*.

For the teachers to ensure the implementation of the curriculum, and the achievement of the scientific thinking and skills by science learners, strong pedagogical content knowledge (PCK) (Shulman, 1987) is required to help learners make sense of what they are learning. Strong PCK may also help teachers to demonstrate and explain what they would like to convey to their learners in their science classrooms. According to Nakale (2012), providing and adopting different teaching strategies can develop non-first language learners' ability to comprehend science mediated in English. He further argued that strategies that can be used by the teachers to convey a particular content can be influenced both by the teachers' content knowledge and the challenges of the learners.

In the lessons observed (Appendices 5A-D), in their everyday lesson presentations teachers used different teaching strategies to scaffold and mediate learning in their Biology classrooms. That resonates well with Schulman's (1987) views on the PCK required by teachers. Observation showed that individual teachers' PCK influenced their choice of approaches for planning, structuring and presenting the topic respiration. However, Schulman put an emphasis on the diversity, interest and the abilities of learners as individual beings, that should be catered for during planning and presentation. For example, L4 presented information to T1 that she was not aware of as shown in their conversation below:

L4: Now mrs,……the yeast reacting with sugar…..acohol…If we bake what will happen?

T1: What are you saying again?

L4: The yeast if react with sugar, now when you bake what happen to gluton?

T1: I don't know. What is gluton? Is it an enzyme or what? I thought you are talking about enzyme. I don't know you can go further.

L4: Is a protein….it produces an enzyme…then when the gluton…

T1: What is gluton? Is it a substance or a protein?

L4: Is a product, is a product, an end product of catalyzation of sugar..

T1: Yee, ok. A product of ……

L4: Catalization

T1: Now, I don't know. Is it a product or a dough itself? No. it…on a bread. It is a protein again?

The above conversation shows that T1 needed to familiarize herself and be well acquainted with the content to present to the learners. In addition, although T1 asked higher order thinking questions, some of the questions asked were confusing (Appendix 5A, Line: 68). For example, *What are the organelles we need to know? What are the examples of these cells?* Many learners answered in a chorus: *Not sure!* Their negative responses may be due to the way the questions were asked or rephrased. Based on the same questions, *L16* answered: *Nucleus,* but in fact, the nucleus is not a cell is a component of the cell. This kind of subject matter knowledge (SMK) may create misconceptions and complicate students' understanding of respiration and its concepts.

Based on the lesson observation of the two teachers, the types of questions asked were relevant and could encourage thinking beyond the obvious answers. Learners where also interested to ask questions beyond the teachers' expectations as illustrated in the conversation below (see also Section 4.9.1).

L6: When you put a lot of yeast in the dough what will happen?

T1: A lot of what? Did I say put a lot?

L6: No mrs, I am saying if you put a lot of yeast?

T1: Why do you have to put a lot? Are you not conservative enough?

L6: I don't mean like that?

Based on learner centred approach which is recommended by the curriculum, the conversation above indicated that learners were aware of and implementing this approach together with their teacher. This is evidence of interaction in a learner centred way as L6 came up with a different idea to think of; what will happen to the dough if the quantity of yeast is increased? This is supported by social constructivism discussed in Section 2.5. However, a learner with low self-esteem might well withdraw from asking questions when a teacher's responses are very sharp.

To this end, Kasanda, Lubben, Gaoseb, Kandjeo-Marenga, Kapenda and Campbell (2005) argued for the relevancy of the learning content to be contextualized to the learning needs of learners (Section 2.2). This argument echoes well with Roschelle (1995), Rennie (2011), Kibirige and Van Rooyen (2006) and the main reason for contextualizing is to give learners opportunity to extract from their home or outside school experiences, and link that to their school science experiences. At the same time, the context of learners, if properly used, may ensure smooth crossover from already known knowledge to the new knowledge intended to be introduced to them. Thus, learning about the importance of respiration based on real practical examples could enhance and promote learning with understanding. For that reason, the Teacher

Education in Sub-Saharan Africa (TESSA) (2012) illustrated the essentials for teachers to align their mediation with the topic's relevancy to learners' context and real world as discussed in Section 2.2.1. This strategy could also reinforce scientific principles that were mostly lacking in their responses as reported by Examiners (Section 4.5.5). The relevancy of practical exercise in lessons but not limited to classrooms can also help teachers to scaffold learning on respiration in particular and help them to make sense of the associated concepts. At the same time, it may enable smooth application of knowledge obtained through these lessons that may help learners to solve their own problems and even national problems. For example, they may contribute to employment creation by being involved in brewing and bread making in small enterprise industries.

Thus, the knowledge and skills discussed above were determined by the teachers' PCK, their understanding and commitment toward what they were mediating. Thus, Shulman (1987) suggested that teachers should be mindful to infuse the content knowledge and the pedagogy to teach their learners considering their 'Zone of Proximal Development' (ZPD) (Vygotsky, 1978). Yet, in this study T1 demanded and restricted learners to stick to the definition in the textbook, although different textbooks define respiration differently. I therefore suggest that where definitions appear in the syllabus as indicated in Table 4.1, theme 8.1 and 8.2 the first bullet, which should be standard definition to be adopted.

5.3.2 Analytical Statement 2:

Use of learners' prior knowledge to scaffold and help them make sense of concepts in respiration

In this study, the term *prior everyday knowledge* was used to refer to any kind of knowledge learners held about respiration. This research showed that the way we introduce the lessons in our classrooms has a great impact on learning.

The teachers in this study were able to share their views, their experiences and the challenges they faced when mediating learning of respiration. Both teachers indicated that they used learners' prior everyday knowledge as a point of departure. Class observation showed that they had a good understanding about prior knowledge. The curriculum document emphasised that learning in school must relate to, involve and extend learners' prior knowledge and experience (Ministry of Education, 2010). That is, teachers should make use of learners' prior everyday knowledge and this can be wisely done when they are aware of their learners' everyday knowledge in order to introduce them to unknown concepts.

It emerged that the two teachers employed prior knowledge differently. I observed that both made connection from what learners already learned and they mostly referred to what had been learnt in the previous grade. But teacher 2 made good contextualization, shortly after the introduction when she said "*Why respiration is important for life?* This question also demonstrated the relevancy of the concept to learners' lives. This had helped learners to think critically and make sense of the topic by relating it to themselves. In contrast, teacher 1 asked only "*what is respiration"* with no further probing that allowed learners to recall only. These types of questions are also limited during final examinations (Section 4.5.1). This study suggests teachers to ask questions that encourage critical thinking.

The two teachers interpreted the curriculum differently, and this might be due to their different experiences, creativity, own exposure, confidence in their learners or interests they have in the subject. When one of the learners said respiration only takes place in living organisms (Appendix 5C: LO1T2), Teacher 2 asked "*Who said only in animals? Why in animals only?"* This could allow learners to think and reason as to why they said so. She then gave feedback to their answer by explaining and referred learners to the 7 characteristics of living organisms. In contrast, if she had just pointed out that plants are also living organism without relating it to the characteristics of living organisms then tension could develop (Roschelle, 1998) between their experiences and the knowledge the teacher intended to convey. There would also have been no smooth cross over, a situation described by Kibirige and Van Rooyen (2006).

The questions and explanations built a strong foundation for learners to develop their understanding of the new concepts of respiration. This resonates well with Lemke's (1990) recommendation of teaching learners to 'talk science' using convenient mediational tools that can help their learners' to communicate precisely.

Teacher 2 explained the topic they were busy with, and the information given was also available in textbooks in her learners' possession and she could encourage learners to do self-explorative work before and during the lesson, which was her response as to why she did not write notes for learners (Section 4.5.6.2). In contrast, teacher 1 gave learners notes in her lesson presentations, and argued that learners may not know what they have to learn from the textbooks and thus, may end up copying everything which in turn might create misconceptions (Appendix 3C, FI Transcript: Line 33-46). Teacher 1 seemed to be very concerned and understood her role as a facilitator, a guide to mediate learning in her science classroom as discussed by Nyambe (2008). In her response to follow up interview questions (Appendix 3C, FI Transcript: line 23-24) she illustrated how she used Examiners' reports to emphasize scientific concepts. However, although the good narrated descriptions were given by teacher 1 in the follow-up interview, there was no indication in learners' workbooks showing the implementation of what she had claimed. However, it was encouraging to see the emphasis of some errors in the Examiners' reports as she indicated (Appendix 5A, LO1T1: Line 74-75).

This research revealed that the teachers' efforts to involve learners at all level of their lessons was not maximized as they generally assumed that learners were already in a better position of understanding what was going on in their lesson presentation. It is urged that teachers need to dig deeper to get insight into their learners' prior knowledge in order to identify what they are confused about and find better strategies to organize their naïve ideas into coherent and sense making ideas (Kinchin, 2000) and to clear up any misconceptions they may hold. Tyson (1999) critiqued the use of prior knowledge as may inhibit and cause conflicts for the acceptance of scientific concepts. Taylor (1999) also felt that the unstructured nature and wideness of prior knowledge, presents obstacles to considering individual everyday knowledge.

During lessons observed, I found that learners had many questions on fermentation, some asked its meaning and others were trying to link this process to the community practices they observed (Appendix 4D: line 160-167). However, teachers did not think of how they could help learners to understand fermentation concepts by establishing connection to community practices. At least they could have invited an expert from the community to demonstrate traditional ways of making '*maheu', 'otombo', 'oshikundu*' and cultured milk. To support this argument, Oloruntegbe and

Ikpe (2011) expressed that learners' prior everyday experiences allow them to relate what they learned in school to what they experience at home or in their environment. In their study conducted in South Africa, Stears, et al. (2003) presented similar views. They noted that incorporation of learners' everyday knowledge in science can enhance learners' involvement and engagement during appropriate mediation of learning in science.

Uushona (2012) has carried out a successful research in which community expert was involved in brewing of *Ombike (traditional brew)* and learners were observing and were able to ask questions. That approach could also allow learners to establish that community members can also contribute to learning and that they are the source of information that can be learned in science. Unfortunately that did not form part of the teachers' agenda during this research, otherwise it could be a learning experience for future implementation (see Appendix: 5A-D).

Many other researchers (Taylor, 1999; Tyson, 1999; Kuhlane, 2011; Nakale, 2012; Homateni, 2012; Uushona, 2012) have contributed to the role of prior everyday knowledge and its contradictions if not properly incorporated in science as discussed in Chapter 2, Section 2.3.2. Therefore, there is a need for science teachers to dig deep in order to construct and frame their planning in line with the curriculum and their learners' needs as well as considering the issues around the use of prior knowledge as discussed in Section 2.3.2. This study identified the gap in the use of prior knowledge by the participant teachers, as they focused those efforts on the introductory part of the lesson ignoring prior knowledge in the rest of their presentations.

5.3.3 Analytical Statement 3:

The role of practical activities in conceptual attainment in learning respiration

This study revealed that teachers showed willingness to incorporate practical activities in their lessons as indicated in their lesson plans (see Appendices 5B & 5D). However there was a mismatch between what was planned and what was presented. It was found that practical activities were not implemented as planned and this was one of the concerns identified by this study. The practical lessons were rather taught theoretically, and many questions that learners' had during the part on brewing and bread making (see Appendices 5A-D and some critical moments presented in Chapter 4) could have been addressed through involving learners into practical activities. This would have allowed them to observe how things happen and they would have been able to get scientific explanations and proof where applicable, thus, learners have missed out this opportunity a challenge (research question 3) that need to be improved.

The nature of practical activities and the recipe of design determine the level of interest for learners. Practical work should be carefully and well planned in advance to attract learners' interest and promote engagement with the lesson as discussed in detail in Chapter 2 (Section 2.3.4). Hart (2003) supported practical activities and in his view, practicals reduce the linguistic barrier for non-first language English Language Learners (ESL) (Section 2.3.3) but this was not considered in the lessons observed, a response to research question 3). This might also be true for teachers as found by the research conducted by the University of Namibia (2012) based on the English Proficiency Test results, as discussed in section 2.3.3, challenging participants in teaching and learning as revealed in this study. The findings of Woolnough (1994), resonated well with that of Hart (2003), that doing science in school is a holistic experience involving the mind and the hands and they warned educators not to pay attention to knowledge and skills only but rather knowledge and skills should be facilitated through practical activities but not in isolation (ibid) as a case in this study's findings.

Despite the benefit of practicals being highlighted in the curriculum of Education and the explicitly described proposed practicals in the Biology syllabus (Section 2.3.4), the two teachers did not conduct any practical activity around the concerned topic. Instead, theoretical knowledge played major roles as reflected in their presentations (Appendix 5A-5D). That made it difficult for learners to strike a balance between theoretical knowledge and its application through practical activities; hence interventions discussed in Phase Two were necessary.

Millar (2004) agreed that practicals give opportunities for learners to manipulate objects in the school or outside the school setting, but none of the setting was considered to carry out practical activities based on the lessons observed from both participant teachers. Recognizing the profound significance of practical activities, Millar (2004) described the importance of visualizing real objects and situations as more powerful, as discussed in Section 2.3.4. As a result of practical activities, misconceptions are confronted and as events and phenomena transpire, explanation of events is organized in acceptable scientific ways. Analysis of the lessons observed showed that the teachers assumed that learners understood the ideas behind practicals through merely theoretical information being given to them, contradicting the syllabus directives. This study affirmed the need for teachers to conduct practicals, despite the challenges they indicated in the questionnaire (Appendix 3C: line 36-46, & Appendix 3D: line 27-32).

As an example of failure to use practicals, teacher 2 indicated that she was supposed to bring self-rising flour to demonstrate bread making and the role of yeast for learners to observe. This shows that she was aware that a practical activity could bring better sense making and establish reality on the ground even where language was a constraint. Despite such knowledge being reflected in the lesson plan for teacher 2, both teachers did not use the practical method in the lessons observed. When asked for the reason the practical had not been carried out, teacher 2 expressed a concern of lack of practical chemicals and equipment. Thus, I suggested, if they can use locally available resources and community members to make use of indigenous knowledge. In turn that has led to '*ahaa*' moments that captured the attention of teachers. Hence, the establishment of team works to co-design practical activities on respiration as a response to limited practical resources in the two schools and equally addressing research question 4. This collaboration is discussed in Sections 3.3.3, 5.3.3 and 5.3.6.

Based on the directive of the syllabus on practicals activities (see Table 4.2), National Policy guidelines and textbooks, teachers should make use of this strategy more often as it creates a better platform for sense making through social interaction. To add weight to the above, Hodson's (1990) findings showed that if learners are allowed to do practical activities it motivate them and attach value to science, which is opposed by the findings of this study. He added that it further stimulates their interest to learn and enjoy laboratory skills which in turn promotes conceptual understanding of scientific ideas, scientific methods and develops skills for application to their context. These good ideas were ignored based on this study's findings.

While appreciating the benefits of practicals discussed above and in Section 2.3.4, Hattingh, Aldous and Rogan (2007) believed that the type of practical activities and the methods depends largely on the decisions of science teachers. They further emphasized that teachers who are motivated will always find a way to carry out practical activities with their learners even in the most poorly resourced school (ibid). Therefore, my study intentionally exposed participating teachers to some ways of improvisation as a way of contributing towards quality inclusive education in a science classroom (see Phase Two). This was thought to be relevant and appropriate because many studies (Hodson, 1990; Maselwa & Ngcoza, 2003; Stears, et al., 2003; Millar, 2004; Roberts, 2004; Hart, 2003; Hattingh, et al., 2007) have pronounced their findings based on this theme as discussed in Section 2.3.4.

The analysis showed that many practical activities in other topics were also not carried out as they were not reflected in learners' workbooks or summary books. Proper monitoring of teachers' activities in schools appeared to be a major concern. Learners would be denied their right to quality education and consequently, to the opportunity to visualize and conceptualize science, to see the relevance and significance of Biology in general and respiration in particular as presented in Section 2.2.1. If learners do not see the relevancy of learning science in their real world, they can hardly get interested to learn. Thompson and Logue (2006) argued that when misconceptions are not identified and unlocked as early as possible, they are likely to block the path of conceptual understanding. Drawing from this and other studies documented in Chapter 2, this research encourages biology teachers to explore different ways to scaffold, give sufficient support to learners and effectively enculturate them into biological concepts.

Nakale (2012), Homateni (2012) and Uushona (2012) conducted studies in Namibia in which they discussed the role of practical works in science classrooms. For instance, Nakale (2012) expressed that doing science in school is a holistic activity involving the mind and the hand. He added that practical activities reduce rote learning as they promote conceptual development and understanding. Based on the above argument, and as outlined in the Biology syllabus and pronounced well in the National Subject Policy guide lines and highlighted in textbooks, teachers are expected to make use of practicals. However, this did not transpire in the teachers' presentation despite being mention in their lesson plans. The reasons for these are sound as practicals are better platforms for involving learners seeing that learners do the practicals themselves and make meaning through social interaction (Nakale, 2012). Homateni's (2012), experience of involving learners' in doing practicals about a rainbow resonate well with Nakale's

(2012) views. She found that learners' responses to her questions based on rainbow activity referred to what they experienced at home. She then framed these experiences into scientific ideas through refining their existing experience or eliminating their misconceptions, which could be good lessons other teachers can learn from.

Uushona (2012), in his study of brewing Ombike, consulted a community member to demonstrate and attend to learners' questions based on that activity as discussed in Section 2.3.4 which may be a response to my research question 4. He found that learners could establish the importance and the connection of home and school experience with regard to science and that conceptual understanding were enhanced to a certain degree (ibid). Related findings were also expressed by Nakale (2012) and Homateni (2012) as discussed in Section 2.3.4 which was often ignored as revealed by the study and can be good examples to current and future teachers as well.

The above discussions suggest that the teachers' content knowledge needs to be strong to affect learning in science lessons as discussed in the ensuing paragraph.

5.3.4 Analytical Statement 4:

Teaching strategies used by teachers to scaffold learners when mediating the learning of respiration

The two teachers used different teaching strategies but observation showed that these strategies were not wider enough. Sometimes the teachers found it hard to make a point that learners could understand. Since some learners were Oshiwambo speaking, the mother tongue of both teachers, that could be used and then these learners could translate into Afrikaans which was understood by all learners though not by the two teachers.

Jalal (2010), argued that instructors who would use code switching as a teaching strategy were not doing justice to their learners and were not exemplary (Section 2.3.3). On the other hand Mastura, et al. (2013) presented their case that educators should view code-switching as a strategy and gave reference of using code-switching to emphasize a point to the audience, but this was not a case in this study, though some difficulties in communication were observed.

Teacher 1 used a concept map as proposed by Tekkaya (2012). But Tekkaya cautioned teachers to avoid excessive factual details during instructions as it would confuse learners (Section 2.2.4) opposed to sense making supported by research question 2. Maselwa and Ngcoza (2003) suggested the use of practical activities to promote conceptual development and scientific processes skills as it involves the hands and the mind of learners. However this strategy was not observed during the research process (Appendices 4A & 4B) and has raised a concern since it is a syllabus directive, supporting the significance of research question 3 (Section 3.3.2).

Nakale (2012) also applauded the effective use of scientific language (Section 2.3.3) for meaningful sense making, and the use of prior everyday knowledge (Section 2.3.2), complementing Rochelle's (1995) work and in support of the curriculum (Section 2.2). Teachers made use of prior everyday knowledge and there was some evidence of that, supporting teachers' views expressed in the questionnaire (Appendix 3C). For instance, both teachers asked learners to define the concept of respiration from their previous grades and this at least showed cognizance of the value of learners' input as reflected in lesson observations. This strategy helps learners to link what they learnt previously as a foundation to build on what is presented to them. This supported by the Namibian curriculum of the Ministry of Education (2010). I would however encourage teachers to look at various angles when using learners' prior knowledge in their lessons and to use prior knowledge throughout the topic, not only at the introductory phase as reflected in their responses to the questionnaire.

The use of a variety of teaching strategies enables teachers to recognize the diversity of learners. However this choice should be 'mindful' (Vygotsky, 1978) when deciding on the activities to be learned. That would help each individual teacher to organize his/her PCK into a concrete and concise structure to suit their learners' needs. There were times when learners were reading in groups but the reading activity was not worthy of grouping seeing that learners were reading aloud to the whole class and all had the same materials at hand. For instance, (Appendix 3C, T1T2QR: line 30-32) learners were seated in groups throughout though I did not observe learners doing an activity in groups. Although grouping learners is believed to be a learner centred approach enabling learners to use their first language to mediate learning, merely grouping learners would not yield good results, a challenge congruent to research question 3. This suggested the teachers' inability to use appropriate PCK that suited the learners' needs and they need to be selective and focus on the strategies that best work for the way their learners learn. Teacher 2 did not give ample time to learners to think and respond to questions posed to them and as a result, the teacher ended up giving answers to their own questions. This was also a challenge faced especially by teacher 2. In addition, more teacher talk was observed (Appendix 5D, LO2T2: Line 38-57) and analysis of her conversation suggested that in some cases learners' were regarded as empty vessels into which the teacher had to pour the knowledge which is opposed to (Roschelle, 1995).

On the other hand, it was observed that both teachers enforced probing by encouraging learners to reason from their ideas, for instance, in this conversation:

T2: Who said only in animals? Why in animals only?

L5: Is it a question? T2: Yes. The question is, if is only in animals but not in plants? Why you are saying so? You must have a reason for that.

In my observation of all the lessons observed, teachers did not give opportunity to learners to make use of the chalkboard, which is identified as a shortcoming. Thus, I would recommend as part of the answer for research question 4, a refresher workshop on teaching methodology to enlighten the daily execution of the curriculum.

5.3.5 Analytical Statement 5:

Challenges faced by teachers in relation to mediation of learning of respiration

The findings presented in Chapter 4 revealed that the two teachers were faced with some challenges including use of practical activities; availability of equipment and chemicals, and the use of prior knowledge and language of instruction. Most of these challenges could be condensed under pedagogical content knowledge (PCK). Under analytical statement 1, challenges were raised with regard to teachers' failure to meet curriculum requirements. In this section the same PCK lens is used to discuss other challenges faced by the two Biology teachers regarding mediation of the learning of respiration.

Pedagogical Content Knowledge (PCK) as discussed in Section 2.6 is briefly the blending of content and the pedagogy into an understanding of how particular topics, problems or issues are organized, represented, and adapted to diverse interests and abilities of learners, and presented for instructions (Shulman, 1987). This study revealed that the two teachers had limited content knowledge regarding practicals which could have made learning more meaningful, fun and interesting to learners. The follow up interview answers in relation to research question 3 (Appendix 3D, RQ10: Line 28-32) when T2 was faced with problems of not conducting practical experiments she reasoned that *learners are willing to do experiments but due to lack of equipment, experiments are not being done in Biology. She added that, there are not even workshops conducted to give them information on doing experiments (a proposed response to research question 4). Furthermore, T2 referred to a practical Paper 3 in Biology as most difficult for learners as they mostly do theory rather than practical activities. She reiterated that it is a major problem and it makes them perform poorly in Biology as the practical Paper contributes more marks than Paper 1.*

Analysis of these statements suggested that teacher 2 was challenged about how to plan and set up practical activities and this is an answer to research question 3. This is shown in her complaint about a workshop not being conducted to give teachers skills in manipulating the practical equipment used in Biology. The teacher was aware that learners find the practical paper in Biology to be more difficult because she concentrates on theory during teaching while practical activities were often ignored since no workshops being conducted on how she could carry out practicals. In essence, T2 knew the factors contributing to poor performance in Biology especially in Paper 3 as evident in follow up interview transcripts (Appendix 3D: RQR10).

In Chapter 4, several examples were given which supported the claim of lack of content knowledge to conduct practical activities within and outside the classrooms. These claims were also made in the Examiners' report as learners did not perform well in paper 3. This study supports those claims. For example, the following errors were made during lesson observations: *Oxygen goes straight to the lungs, using the term 'organelles' interchangeably with 'cells'* and as shown in Appendix 4D, LO2 & 3T2: Line 35-38). This trend would be problematic for all educators concerned with quality of education in our schools. They show that teachers' subject matter knowledge (SMK) is insufficient and reveals the need for intervention to address the situation, an answer to research question 4 and also discussed in my recommendations in section 6.3. If these problems go on unattended, many learners are likely to remain and suffocate within the limited content knowledge of their teachers, especially those learners who heavily depend on teachers' support for mediated learning (Presseisen & Kozulin, 1992).

Another challenge that the two teachers were associated with was insufficient support from the Advisory teacher specializing in Biology. The issue of insufficient support could not be confirmed in this study, other than the claim by one teacher that there were no workshops conducted to give them information on doing experiments. The reality is that these teachers need to be guided on how to order laboratory equipment and be trained on how to manipulate it and this may be an answer to research question 2 and 4 as well.

These schools were rich in terms of textbooks as each learner in a Biology classroom had at least three different types of textbooks commonly used in their lessons as mentioned in Sections 4.5.1-4.5.3 and confirmed by teacher 1 (Appendix 4A, LO1T1: line 23-24). In addition, both schools had access to the internet, but throughout my lesson observations I did not see any use of internet support materials by either the teachers or the learners. In contrast, T1 indicated in the questionnaire transcripts that she would use the internet to search information and acquaint herself with the subject content (Section 4.6.1 and Appendix 3A, T1T2QRs: Line 49-51).

While accepting the mistakes noted in some of these textbooks analysed (addressing research question 2), for example, the absence of describing the state of matter, teachers may be cautioned to plan and prepare their lessons to eradicate misconceptions rather than creating them. The teacher- learner ratio in the observed lessons was the reasonable 1 to 32, suggesting that these schools could still do well with the provision of available resources. This means that the teachers may have had sufficient time to attend to their learners' problems.

Other challenges observed were related to inconsistent use of scientific language (Appendix 4A, LO1T1: Line 66) also addressing the research question 3. In such cases the teachers attempted to simplify terms and in doing so changed the exact meaning of what they wanted to communicate, and in turn making it hard to communicate scientific information as discussed above. Learners' performance in the examinations may suffer as they are expected to answer using accepted scientific terms and explanations. When the language used does not facilitate sense making of the scientific concepts then acquisition of the required knowledge would be limited. For these reasons, Nakale (2012) proposed the incorporation of various flexible pedagogies to support the learners, such as practical activities, prior everyday knowledge and analogies. These strategies are considered in an attempt to answer research question 2 and 4.

5.3.6 Analytical Statement 6:

How teachers can be supported to help their learners make sense of respiration and its concepts

Sections 4.6.1 and 4.6.2 reported on teachers' responses to the questionnaire. One feature was the reported lack of support despite teachers' willingness for in-service training through workshops as indicated in the follow-up interview questions. Teacher 2 expressed the need for concrete models and materials to demonstrate to learners on respiration and other challenges were presented in Section 4.6.1 and discussed in Section 5.2.4. When given an opportunity to reflect on their lessons, both teachers indicated that their lessons went well generally, because the learners were participating and asking questions. However, learners' participation may not necessarily mean good lesson presentation. I would argue that the teachers' self-evaluation of their lessons was defective. A typical example was referenced in Chapter 4, where T1 who thought that organelles and cells were synonymous and she used these words interchangeably to ask learners about the site of respiration, answering research question 3. I also advised Teacher 1 to improve on her techniques of asking questions seeing that most of the time her responses discouraged learners from asking further question or giving answers. Teacher 2 consistently stood at the front of her class, which may be a source of future disciplinary problem among learners, a further challenge needing to be addressed.

Section 2.6 drew on the work of Geddis, Onslow, Beynon and Oesch (1993) with regard to the Pedagogical Content Knowledge (PCK) required by teachers. The PCK concept expects teachers to infuse content of the topic with appropriate methods to effect mediation. Geddis, et al. (1993) warned teachers to refrain from unproductive approaches. Since in this study, the PCK of teachers was found to be limited as illustrated above and presented in Chapter 4, I felt it might be helpful if alternative support could be rendered to the participant teachers to strengthen their PCK.

As an agent of change I felt it was necessary to support teachers to improve their teaching, especially their practical skills, in an attempt to minimize the gap between planning and practice. I persuaded the two participating teachers to co-develop model practical activities and a unit of work. The intention was to develop the teaching and learning support materials together with the teachers to get their inputs and minimize difficulties in implementing the planned activities. As a reflexive researcher, I was aware of the power dynamics between me and the participating teachers and tried by all means to level the power difference so as to achieve collaboration in research rather than command and control. The idea was to collaboratively develop practical activities that would strengthen my relationship with the participant teachers. To add weight to that, working together enabled us to share ideas. The idea was to establish a community of practice (Lave & Wenger, 1991) that is a group of people who share a concern or a passion for something they do, and learn how to do it better as they interact regularly.

The two model lessons (see Appendices 6A and B) were developed with the cooperation of the two teachers. The model lessons come as a response to one of the challenges noticed during observation when either teacher conducted practical activities as stipulated in the syllabus. Thus, this was an effort to support them and to answer research question 4. However, these practical lesson activities were not intended for use in this study, but as an extension. Implementation would be needed to determine the outcome of the intervention and teachers were clearly informed to use them for revision purposes. These model lessons do not restrict teachers from going beyond this support. For instance, teachers may perhaps incorporate inquiry based learning, real-life experiences (Rock, 2011) (Section 2.2.4), or use technology such as accessing YouTube internet resource, to observe how such a topic is presented in the other parts of the world.

The insights from the lessons suggested a need to co-develop model lessons on practical activities as these planning tools were not part of any lesson observed for either teacher 1 or 2 and this was one of the answers to research question three. Also, the idea of co-development of model lessons arose as a response to research question four. The co-planned practical activities developed in this context are referred to as learning and teaching support material (LTSM). The LTSM was written in a simple, step by step style and hopefully can be useful to both teachers and learners. It contains a combination of strong qualities extracted from the analysis of textbooks presented in Sections 4.5.1, 4.5.3 and 4.5.4. In addition, other helpful features such as case studies were inserted to illustrate the relationship of concepts underlying respiration and to make teaching and learning fun (Appendix 6C). Though this study made some effort to support teachers to improve their practice, the study findings suggest that more support would be needed from lesson planning, preparation, presentation and pedagogies.

5.4 Concluding remarks

In this chapter the data generated from document analysis, questionnaires and observation was analysed, interpreted and discussed. Five analytical statements were derived from the data generated. These statements enabled me to structure and allocate data within each analytical statement. The data reflected on how two teachers were mediating learning and supporting their learners to make sense of the concepts underlying respiration.

The Pedagogical Content Knowledge (PCK) of teachers regarding curriculum issues, the way they used learners' prior everyday knowledge, the role of practical activities, the teaching strategies used and challenges teachers face were discussed. This study acknowledged some good practices observed but it has also identified areas for support. Thus, this study applied some techniques to support teachers improve their teaching of respiration through collaboratively working together. In this context, we worked together as a team to have a concrete product that can be helpful in teaching and learning, and in turn this has provided an answer to the research question 4.

In the next chapter the findings of the study are summarized, which culminated in recommendations, the limitations and areas for further future research. I also provide my critical reflections on my research journey. Finally, I draw a conclusion to the study.

Chapter 6: Summary of findings, recommendations and conclusion

6.1 Introduction

This chapter presents a summary of the research findings and suggests some recommendations that could be implemented within the Namibian Education curriculum and elsewhere particularly with regard to how teachers scaffold learners to make sense of respiration and its concepts. This chapter also makes general recommendations and suggests areas for future research. Finally, in this chapter I discuss the limitations of the study and give some personal experiences, reflections and lesson learned throughout this research.

6.2 Summary of findings

This study revealed how two Biology teachers scaffold learners to make sense of respiration concepts during mediation of learning, the challenges faced and some of the techniques that teachers used despite the challenges faced. The findings were derived from teachers' views and experiences when incorporating the prior everyday knowledge of learners into their lessons. Two sites were chosen in this research in an effort to provide possible answers to the learners' poor achievement in Biology which frustrates their efforts to qualify for admission to tertiary institutions.

The findings of the study providing insights on best practices that are worth emulating and areas that need improvement in the science classrooms observed from two sites.

As pointed out earlier in Section 2.2, prior everyday knowledge stimulates learners' thinking and fosters a conceptual shift in viewing science. Neglecting of prior everyday knowledge, such as could be provided for instance by experiments on traditional brewing or bread making could make it difficult for learners to comprehend scientific concepts of fermentation (anaerobic ,respiration) and how lactic acids are produced. To emphasise this, Roschelle (1995) pointed out the importance of prior knowledge as it allows smooth crossover from known to unknown, incidentally congruent to the Curriculum of the Ministry of Education (Section 2.2.).

Thus, an initiative for co-planning with teachers to explore traditional ways of brewing and bread making were worthwhile in an effort to encourage teachers to conduct practical experiments through improvisation using natural locally available resources. Furthermore, co-development of a unit of work on respiration was also crucial as it gave insights on how to make learning of this topic fun, lively and contextualized to the real world of the learners. Since the syllabus or the curriculum does not specify exactly the type of prior knowledge to be considered during teaching and learning of this topic, the findings suggested that the challenge to some teachers is that they may not be creative enough to realise the relevance of local knowledge. Consequently, some teachers will ignore prior knowledge during mediation of respiration. Yet, such prior knowledge could be used to expatiate on the relevancy of the topic to the learners' life and that of their community and nation.

The study further revealed that the Biology teachers involved in the study did not often employ a variety of teaching strategies to scaffold learners in making sense of respiration concepts. It further revealed that the limited use of different teaching methods by these two teachers was due to lack of teaching resources and practical equipment as they indicated from interview responses. It is imperative for Advisory teachers to be constantly in contact with teachers to help them on how to access laboratory equipment for practical activities. In addition, Biology teachers would be advised to use locally available resources for effective learning.

Through observation of lessons taught by the two teachers, it was found that participating teachers had a fair subject content knowledge of Biology, and respiration in particular. Despite that, due to an insufficient effort in pre-planning insufficient exposure to different learning styles and limited understanding of learners 'Zone of Proximal Development' (ZPD) (Vygotsky, 1978), they made numerous errors and contradictions during their explanations, that might have created misconceptions among learners. This research also found that lack of proper pre-planning and preparation of lessons was associated with poor monitoring by school authority, which would be contributing factors to low achievement of learners in Biology. This is shown by very few activities being given to the learners during the time of observation.

Sufficient evidence was found that participant teachers were facing challenges in mediating learning in science at least for this topic (Section 2.2.2). For instance, neither school had laboratory apparatus to involve learners in practical experiments which would have enhanced their engagement with learning activities and for conceptual understanding. To overcome some of these challenges, Rennie (2011) contended that engaging learners in exploratory activities may also help the teachers and learners to close the gap between scientific knowledge and everyday experiences. Thus, planning beyond laboratory activities may promote learners' understanding of their cultural knowledge and scientific knowledge and bridge the gap between the two. To strengthen Rennie's suggestions, Kasanda, Gaoseb, Lubben, Kandjeo-Marenga, Kapenda and Campbell (2005) also discussed the importance of contextualizing the teaching and learning within learners' contexts to encourage making sense of scientific concepts.

For instance, when I was myself a secondary school Biology learner, I tended to do well when what were taught was related to our daily life experiences and what we did at home or in our community. Things that were associated with my own body in Biology were my favorite topics. Through personal reflection during this research and in relation to the lesson observed I have come to appreciate the need for all educators to make use of prior everyday knowledge as a foundation and as a stepping stone for their learner's departure into and unknown world. The use of prior knowledge helps teachers to identify confusions and design teaching pedagogies that could result in fascinating output (Allen & Tanner, 2005) and this view resonates well with that of Stears, et al. (2006).

Roschelle (1995) believed that neglecting of learners' every day knowledge generally had negative impact on learning. In support of this view, other experts conducting research on prior everyday knowledge reiterated that conceptual attainment of respiration can be only possible if learners are given an opportunity to align their experiences with what they are learning in the science classrooms (Taylor, 1999), emphasized by the Namibian Curriculum. Taylor (1999) found however that not all everyday knowledge agreed with the subject content in the science classroom. Thus, exposure of everyday knowledge through debate, experiments and demonstrated scientific proof allows learners to draw a distinction between myths and scientific knowledge and this was not observed from participant teachers' practices.

In addition, Maselwa and Ngcoza (2003) applauded the use of effective practical activities as these enhance critical thinking as opposed to 'ill-health' practical activities which do not affect learning (Hodson, 1990, p.36). This research showed how important it is for Advisory teachers (those with particular expertise in various subjects) particularly in Biology, to conduct workshops and co-plan practical activities with their teachers. This would not only improve the results for Biology but would also help teachers to form a community of practice where teachers meet with each other, their Advisory teachers and community experts to incorporate indigenous knowledge (IK). The research concludes that a community of practice together with exposure of Biology teachers to improved monitoring and support network from school authority would promote effective measures of scaffolding learners in making sense of respiration and its concepts.

This study was within the context of education reform and transformation in Namibian Curriculum happening soon after independence from colonial control. The reform was influenced by the new teaching approach called learner-centred education (Nyambe, 2008) that requires learners to be at the centre of learning and to take responsibility for their own learning (Vygotsky, 1978). This approach requires teachers to provide learners with opportunities that may help learners' engagement into learning activities. In essence, it could be urged that this research is one of the responses to the Namibian curriculum (MoE, 2010) which encourages the use of prior everyday knowledge, the importance of practical activities in Biology and the use of a variety of mediational tools to help learners to make sense of what they are learning. This research can also be seen as one of the responses to the implementation of the Namibian Curriculum which encourages the use of indigenous knowledge and sharing of experiences between schools and the community members (ibid).

Rennie (2011) urged teachers to be knowledgeable about different everyday knowledge their learners may hold and to find appropriate techniques to make use of learners' everyday knowledge. He further contended that learners' everyday should not be ignored but should rather be used as a starting point of any topic to direct the facilitator on what to present to the learners (ibid).

6.3 Recommendations

Analysis of my research findings provided the following recommendations and suggestions:

1. Science teachers need to be more critical and innovative in their design of lessons and practical activities, improvising to consider indigenous knowledge (IK), using locally available resources to conduct experiments and practical activities.

2. Teachers should consult community members to discuss learners' everyday knowledge based on indigenous knowledge and so help learners' to link school science with the disciplines of home tasks.

3. Seeing that none of the lessons observed included any practical learning activities, that was evidently a challenge Thus, teachers should meet together with their advisory teachers and co-plan and design practical activities as well as other learning and teaching support materials (LTSMs). These needs were evident from finding that learners were using three different textbooks which they are not knowledgeable to use while their teachers did not have enough time to work with all the textbooks in each lesson.

4. Some concepts associated with respiration are not explained in sufficient detail. For example, fermentation process and lactic acid formation in muscles are not presented in detail in the textbooks. Therefore, teachers are urged to consult and find more information possibly by using up to three textbooks to help learners to comprehend the concepts well. The biological terminologies as those in respiration concepts should be introduced in Namibia from Junior Secondary phase for better conceptual development as they move to the senior phase.

5. It appears that most learners could enjoy practical activities as reflected by numerous of questions they asked when both teachers introduced brewing and bread making (Appendices 4B and 4D: line 44, 66-68, 81 & 131-172 respectively). Thus, this research fully recommends teachers to use practical activities as these involve and put learners at the centre of learning (Maselwa & Ngcoza, 2003).

6. Indigenous knowledge on this topic and science in general should be documented to make it easy and possible for teachers and learners to use it as reference especially in cases where the indigenous knowledge is being lost.

7. The lack of content knowledge revealed in this study brings to light the need for teachers to be given workshop and financial study support to revive their content knowledge regarding their specialization.

6.4 Suggested areas for future research

Based on the findings of this study and for any other person who would like to carry out further research on mediation of learning on respiration in Biology, I suggest the following as potential areas for further research:

1. The effectiveness of incorporating indigenous knowledge in learning respiration in Biology.

2. Studies should be conducted to find out about learners' views and experiences learning this topic.

3. Research should be carried out on the same topic anywhere in Namibian or at these two sites to find out the effects and constraints involved in using mother tongue as a mediational tool to teach this topic.

4. Research might be conducted in which learners are taken to both scientific brewing industries and to the community brewing expert to compare the effectiveness of both experiences on learners' learning.

5. Further research on this topic could be done where learners would be involved in doing experiments and completing a worksheet based on what they did to see the effectiveness of practical activities on learners' conceptual development and performance.

6. A study could be conducted to determine if gender has an effect on practical activities of respiration.

7. A large scale research is needed to determine the PCK of teachers in an effort to determine the nature of support to be given to them.

6.5 Research limitations

While carrying out this research, certain limitations were observed as presented in Section 3.10. Changing work environments might have affected the way the study was conducted and consequently its findings too. If I were to carry out this research again, I would request learners to write a test or an activity after the presentation to assess understanding and identify gaps that might require different pedagogical intervention. This would have enabled me to measure how they make sense of the topic, their understanding about the concepts associated with respiration and whether the pedagogies used helped them to comprehend the topic. I would also interview learners after the presentations to find out their views and experiences. It would have been useful to hire a camera operator to video record all the lesson observations, thus reducing workload and allowing the researcher to concentrate on field notes. This would have helped me to capture all the data and avoid missing out any episode during lesson observations.

Furthermore, I would try to include all five secondary schools in the region as this would have helped to generalize the findings.

6.6 Critical personal reflection

I would like to sincerely share my experiences of conducting this research as a novice researcher. When I received an email informing me about my acceptance at Rhodes University, I had more questions than answers in mind such as financial risks, family commitments and many more. I was worried whether I would ever make it, considering the working environment, which was a rural school where there was no electricity and network was a problem. There were times I wished to link my 3G to internet connection to read emails from my supervisors or search for articles related to my study but experienced frustrations. However, I decided that this was a life-changing situation and I was not regretting taking this decision. Instead, it brought me joy of the highest level as I have always cherished the idea of having a higher degree. It has given me an opportunity to offer my contribution to the vision 2030 as a joint effort by all Namibians to develop and strengthening human resources, and most especially for women empowerment. In addition, this study enhanced and aroused my interest in reading as we were engaged in reading from the commencement of this study and it really developed me to become more analytical and shaped me into being a critical thinker.

Through strong confidence, commitment, hard work and encouragement from people around me, I was able to carry on up to this stage though the journey still presents many challenges. Despite the pressure from my workload, family matters and the study activities, I was determined to move further along in company with others. I always had a question of '*If others have done it through the same route, why not me?* It was not easy to come up with a researchable topic but gratitude goes to the supervisors for their endless guidance and motivation. Many things have happened during this process of research. I recall well how in July 2014 I was still critically fixing my chapter two, which I emailed to one of the supervisors and in response he said "you are very behind many people have gone already to chapter 4" I almost lost hope as I was still collecting my data. After a day I reflected on this email after work, and I regained my courage.

There was a time my supervisor at work assigned me to assist Life Science and Biology teachers and learners during holiday classes and that coincided with my contact class at the National Institute for Educational Development (NIED), the Rhodes satellite in Namibia. She also pronounced herself clearly that the Director of Education would not approve any leave in August for the same purpose. I lost hope again since missing this session would be a big loss for me because that is when I could get time to work on my project. For a while I stopped communicating with my supervisors but they were always courageous and one of them wrote saying "*never ever think about giving up". "It is only cowards who die before they are dead!*" Through reflection on these statements I stood on my two feet again to continue this journey despite the challenges. I regained my momentum and renewed interest to work even more energetically up to this point.

Finally, studying with the Rhodes University has been a unique experience for me. The contact sessions were amazing and helpful throughout this research journey. The discussions we had during contact classes allowed open consideration of the themes learned and these were very true to the Namibian curriculum. The main slogan for the academic years 2013-2014 was the African proverb: '*if you want to walk fast work alone but if you want to walk far, walk along with others*'. During the research process all of us were sharing experiences and ideas on how to go about our research design and data gathering tools. Throughout the research process we have been walking far together with others as a metallic bond, thus, this strategy helped me to survive this journey. I feel that other lecturers and supervisors from different universities especially in Africa may need to learn lessons from these wonderful lecturers. In conclusion, I personally felt that if I cannot make it this time, then the lecturers have nonetheless done their part.

6.7 Conclusion

This chapter presents a synthesis of the entire research process. In the first part of this chapter, I provided the summary of my findings drawn from the analytical statements as presented in Chapters 4 and 5. That was followed by recommendations based on the findings of the research. From the recommendations, areas for future research were identified in order to resolve as many problems arising in teaching and learning of science in general, and particularly in the topic under investigation. Limitations that could not go unnoticed during the research process were discussed with suggestions to overcome some of them. A mirror through which to view the entire research process was discussed critically from the initial stage till the end. Finally, this chapter ends with some reflections on the lessons learned from this study as a whole.

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Appendix 1A-permission to the Regional Director

KUNENE REGIONAL COUNCIL
DIRECTORATE: EDUCATION
DIVISION: PROGRAMMES AND QUALITY ASSURANCE
SECTION: TRC

Private Bag 2007, KHORIXAS

Email: ngombeyamyamba@gmail.com

To: Mr. Simon Tsuseb **22 May 2014**
Director of Education

Dear Simon
Subject: Request for permission to carry out a research study at Secondary school 1and Secondary School 2.

I am a newly appointed Senior Education Officer at the Khorixas Teacher Resource Centre (KTRC) in Kunene Region. I hereby requesting permission to conduct a research study at the schools mentioned above scheduled for June to July 2014.

I am a registered part-time student at the Rhodes University, Grahamstown and my student number is 13A6255 from January 2013. I am doing a Master Degree in Science Education. I am now doing my last year and it is a requirement to carry out a research in my field of study. I would appreciate if you will allow me to conduct my research study at these Secondary Schools since my focus will be on Senior Secondary phase.

My research topic is 'Understanding how two Grade 11 Biology teachers mediate learning of respiration and its concepts: A Namibian case study". The insights that will be generated in this study will be published in a form of a thesis and will be accessible to decision makers in education, curriculum developers, educators and Biology teachers in particular for improved achievements in Biology. If I am to be allowed to conduct this study in these schools, I will observe and videorize a maximum of three lessons from each teacher. The teachers will be also interviewed regarding their views and experiences teaching the concerned topic at their spare time with the view to share experiences with them.

The schools, teachers and learners will be assured anonymity that information they will provide will be used for research study purposes only and that the teachers will be allowed to go through the draft thesis to ensure that the information they gave is truly representing them.

Your usual understanding will be accorded.

Yours Sincerely,

Ms. L. Amutenya

Appendix 1B: Permission request letter to the school principal of school 1

KUNENE REGIONAL COUNCIL
DIRECTORATE: EDUCATION
DIVISION: PROGRAMMES AND QUALITY ASSURANCE
SECTION: TRC
Private Bag 2007, KHORIXAS
Email: ngombeyamyamba@gmail.com

To: The school principal, School 1 **30 May 2014**

Dear Sir

Subject: Request for permission to carry out a research study at School 1 Secondary school

I am Laina Amutenya, employed by the Ministry of Education in Kunene based in Khorixas Teacher Resource Centre (TRC) hereby requesting for permission to conduct a research study at your school as from 10-13 June 2014.
I have registered as a part-time student at Rhodes University, Grahamstown and my student number is 13A6255 since January 2013. I am doing a Master's degree in Science Education and I would most appreciate if you would allow me to conduct my research study in your school. I have consulted Ms. Teacher 1, the Biology teacher at your school and she has indicated her willingness to take part in this study.

My research topic is "Understanding how two Biology teachers mediate learning of respiration and its concepts: A Namibian case study". The insights that will be generated from this study will be published in a thesis form and will be accessible to the decision makers, education planner, curriculum developers, educators and Biology teachers for the purpose improve achievement in Biology. Should I get permission to conduct my research at your school, I will interview the Biology teacher in her spare time regarding her views and experience teaching the topic under study. I also observe and videorise three lesson presentations look at lesson plans, learners' written work and share my experience too with the teacher during discussion.

The information that will be given will be treated confidentially and the participants have rights to withdraw. Ms. Teacher 1 will be allowed to go through the draft thesis for rectification. Pseudonyms will be used both for the school, learners and the teacher.

Your cooperation will be appreciated.

Yours faithfully,

____

Ms. L. N. Amutenya

Appendix 1C: Permission request letter to the school principal of school 2

KUNENE REGIONAL COUNCIL
DIRECTORATE: EDUCATION
DIVISION: PROGRAMMES AND QUALITY ASSURANCE
SECTION: TRC

Private Bag 2007, KHORIXAS

Email: ngombeyamyamba@gmail.com

To: The school principal, School 2 **22 May 2014**

Dear Sir

Subject: Request for permission to carry out a research study at School 2 Secondary school

I am Laina Amutenya, employed by the Ministry of Education in Kunene based in Khorixas Teacher Resource Centre (TRC) hereby requesting for permission to conduct a research study at your school as from 24-27 June 2014.
I have registered as a part-time student at Rhodes University, Grahamstown and my student number is 13A6255 since January 2013. I am doing a Master's degree in Science Education and I would most appreciate if you would allow me to conduct my research study in your school. I have consulted Ms. Teacher 2, the Biology teacher at your school and she has indicated her willingness to take part in this study.

My research topic is "Understanding how two Biology teachers mediate learning of respiration and its concepts: A Namibian case study". The insights that will be generated from this study will be published in a thesis form and will be accessible to the decision makers, education planner, curriculum developers, educators and Biology teachers for the purpose improve achievement in Biology. Should I get permission to conduct my research at your school, I will interview the Biology teacher in her spare time regarding her views and experience teaching the topic under study. I also observe and videorise three lesson presentations look at lesson plans, learners' written work and share my experience too with the teacher during discussion.

The information that will be given will be treated confidentially and the participants have rights to withdraw. Ms. Teacher 2 will be allowed to go through the draft thesis for rectification. Pseudonyms will be used both for the school, learners and the teacher.

Your cooperation will be appreciated.

Yours faithfully,

____

Ms. L. N. Amutenya

Appendix 1D: Permission request letter to Ms. Teacher 1

KUNENE REGIONAL COUNCIL
DIRECTORATE: EDUCATION
DIVISION: PROGRAMMES AND QUALITY ASSURANCE
SECTION: TRC

Private Bag 2007, KHOR

Email: ngombeyamyamba@gmail.com

To: The Biology teacher, School 1 **26 May 2014**

Dear Ms. Teacher 1

Subject: Request for permission for Ms. Teacher 1 to be a research participant in my research study at School 1 Secondary School

I am Laina Amutenya, employed by the Ministry of Education in Kunene based in Khorixas Teacher Resource Centre (TRC) hereby requesting for permission to conduct a research study at your school as from 10-13 June 2014.

I have registered as a part-time student at Rhodes University, Grahamstown and my student number is 13A6255 since January 2013. I am doing a Master's degree in Science Education and I would most appreciate if you would allow me to conduct my research study in your school. I would be most grateful and appreciate your willingness to work with me during my research study in your school.

My research topic is "Understanding how two Biology teachers mediate learning of respiration and its concepts: A Namibian case study". The insights that will be generated from this study will be published in a thesis form and will be accessible to the decision makers, education planner, curriculum developers, educators and Biology teachers for the purpose improve achievement in Biology. Should you give me permission to work with you, I will interview you on your spare time regarding your views and experience teaching the topic under study. I will also observe and videorise three lesson presentations, look at your lesson plans, learners' written work and share my experience too with you during discussion.

The information that will be given will be treated confidentially and you reserve rights to withdraw from this research. You will be allowed to go through the draft thesis for rectification of details. I will not use your really name, that of your school or for the learners.

Your cooperation will be highly appreciated.

Yours faithfully

____

Ms. L. N. Amutenya

Appendix 1D: Permission request letter to Ms. Teacher 2

KUNENE REGIONAL COUNCIL
DIRECTORATE: EDUCATION
DIVISION: PROGRAMMES AND QUALITY ASSURANCE
SECTION: TRC

Private Bag 2007, KHORIXAS

Email: ngombeyamyamba@gmail.com

To: The Biology teacher **26 May 2014**

School 2

Dear Ms. Teacher 2

Subject: Request for permission for Ms. Teacher 2 to be a research participant in my research study at School 2 Secondary School

I am Laina Amutenya, employed by the Ministry of Education in Kunene based in Khorixas Teacher Resource Centre (TRC) hereby requesting for permission to conduct a research study at your school as from 24-27 June 2014.

I have registered as a part-time student at Rhodes University, Grahamstown and my student number is 13A6255 since January 2013. I am doing a Master's degree in Science Education and I would most appreciate if you would allow me to conduct my research study in your school. I would be most grateful and appreciate your willingness to work with me during my research study in your school.

My research topic is "Understanding how two Biology teachers mediate learning of respiration and its concepts: A Namibian case study". The insights that will be generated from this study will be published in a thesis form and will be accessible to the decision makers, education planner, curriculum developers, educators and Biology teachers for the purpose improve achievement in Biology. Should you give me permission to work with you, I will conduct interview with you on your spare time regarding your views and experience teaching the topic under study. I will also observe and videorise three lesson presentations look at your lesson plans, learners' written work and share my experience too with you during discussion.

The information that will be given will be treated confidentially and you reserve rights to withdraw from this research. You will be allowed to go through the draft thesis for rectification of details. I will not use your really name, that of your school or for the learners.

Your cooperation will be highly appreciated.

Yours faithfully,

____

Ms. L. N. Amutenya

Appendix 1E: Permission request letter to Parents

KUNENE REGIONAL COUNCIL
DIRECTORATE: EDUCATION
DIVISION: PROGRAMMES AND QUALITY ASSURANCE
SECTION: TRC

Private Bag 2007, KHORIXAS

Enquiries: ***Email: ngombeyamyamba@gmail.com***

To: The parents of Biology learners **30 May 2014**

Dear valued parents

Subject: Request for permission for your child to be a research participant in my research study within the school campus

I am Laina Amutenya, employed by the Ministry of Education in Kunene based in Khorixas Teacher Resource Centre (TRC) hereby requesting for permission to conduct a research study with them at their school scheduled for June-July 2014. The focus of this study however is on the teachers teaching them Biology as a science subject.

I have registered as a part-time student at Rhodes University, Grahamstown and my student number is 13A6255 since January 2013. I am doing a Master's degree in Science Education and I would most appreciate if you would allow me to involve your child in my research study within their school campus.

My research topic is "Understanding how two Biology teachers mediate learning of respiration and its concepts: A Namibian case study". The insights that will be generated from this study will be published in a thesis form and will be accessible to the decision makers, education planner, curriculum developers, educators and Biology teachers for the purpose to improve achievement in Biology. The published thesis will be also accessible to learners for their research and academic skills. Should you give me permission to work with your child, I will observe and videorise three lesson presentations as they will interact with their teacher, look at their written work both exercises and summary books with the view to see how they do things.

The information that will be recorded and captured will be treated confidentially and learners reserve rights to withdraw from this research if they wish. Their teacher will be allowed to go through the draft thesis for rectification of details. I will not use learners' really name or that of their school.

Your cooperation will be highly appreciated.

Yours faithfully,
Ms. L. N. Amutenya

APPENDIX 3A: Pilot Transcript (PT)

Pilot interview questions culminated into a form of a questionnaire [Biology teachers 1st April 2014]

1. **RQ**. How do you introduce your lessons during Biology teaching of respiration?

PT: I elicit the learners existing knowledge with a quiz, where I pay attention on the definition, the equations both chemical and in words. From the answers of the activity it then gives directions as to which areas to focus more attention and to introduce the grade 11's definition which is a bit more advanced than the grade 10's definition and the rest of the content to be mastered will follow thereafter.

(a) RQ. What are your views and experiences on taking into consideration of learners' prior everyday knowledge when teaching the topic respiration?

PT: Learners' prior everyday knowledge helps set the standards of teaching and the teaching methodology to employ. They also help to clear out the time frame and attention the sub-topics should be allocated with. It is really an integral part of how respiration can be tackled and ensures effectiveness in addressing the new concepts while re-enforcing the pre-existing knowledge.

(b) RQ. How do you make use of learners' everyday life experiences in your teaching of respiration?

PT: Most learners are familiar with the making of bread or cake; some of them have first-hand experience. It is therefore an easy example to use as learners can easily relate to this household chore. It intrigues their interest to realise that yeast is indeed an organism and to realise and understand what leads to dough become sour sometimes. Most learners have outstanding questions which aroused from the actual making of bread which are answered by the explanations of these experiments which the content aims to address.

2. RQ. In what ways do you help your learners to make sense of respiration?

PT: Biology as a whole is a perceptual subject, most of the topics become believable once there are observations involved and respiration is no exception. To make sense of respiration I conduct practical activities, where the learners are given instructions to follow and carry out the experiment on their own.

From the experiment learners are required to test for the presence of carbon dioxide using Limewater of Hydrogen Carbonate solution.

3. RQ. What teaching strategies do you use to help learners understand concepts on respiration?

PT: After content has been covered; I assess the learners with class activities and topic tests which are derived from the previous exam question papers and advanced Biology books. This helps maintain the standard and the expectations of teaching and learning. I also incorporate general questions that are related to respiration to help stimulate the learners thinking and create a link between content and everyday life experience.

4 (a) RQ. What are some of the key challenges you face during teaching and learning of Biology lessons of respiration and its concepts?

PT: Some learners have no basics of respiration, knowledge from the previous grade and this implies that basic respiration has to be covered which leads to lack of interest for those that have the basic knowledge. Most learners cannot balance the equations; therefore more time is spent on this part too. Some learners remain convinced that respiration happens in the mitochondria rather than understanding that respiration happens in stages. Most learners would make reference of what their previous teachers said and taking that as the ultimate right answer which makes the teaching and introduction of advanced new knowledge challenging.

(b) **RQ**. How do you address the challenges you face when teaching Biology lessons on respiration?

PT: Give the learners with prior knowledge activities to keep them busy while attending to those that do not have the basic knowledge. More work is also given to learners who do not have the prior knowledge. I also consult my Chemistry colleagues to pay more address the equations.

(b) **R**. How do you address the challenges you face when teaching Biology lessons on respiration?

T1 I normally try to search and read more various books and google on the internet to enrich myself with th required knowledge towards the topic. I also contact other colleagues you might understand the topic for more better th

APPENDIX 3C: COMPLETED INTERVIEW QUESTIONS CULMINATED INTO A QUESTIONNAIRE FOR TEACHER 2 OF SCHOOL 2

School 2

Interview questions to the Biology teachers May/June 2014

R. How do you introduce your lessons during Biology teaching of respiration topic?

T1 I ask them the following Questions (a) Where do we get our energy from. (b) what is the formular for photosynthesis. (c) why do we need Carbohydrates.

R. What are your views and experiences on taking into consideration of learners' prior everyday knowledge teaching the lessons on respiration?

T1 Its important as learners understand this topic better if they build on what they know.

R. How do you make use of learners' everyday life experiences in your teaching of Biology lessons on respiration topic?

T1 I ask learners to run at least 3 rounds as they will know that when they exercise they use up energy, they require oxygen and some can even get a feeling of anaerobic respiration.

R. In what ways do you help your learners to make sense of the topic on respiration?

T1. I make sure they know the diffinition, the formular and why they need respiration by telling them an example of an anthlete when they run they breath faster, or some fainting due to lactic acid.

R. What teaching strategies do you use to help learners understand concepts on respiration?

T1 Learner centered, where I give them question to answer / then I can comeup with a way to help them depending on what they already understand.

R. What are some of the key challenges you face during teaching and learning of Biology lessons on respiration and its concepts?

T1 , Chemical equation of anaerobic respiration , The 2 equations of anaerobic respiration as learners always get confused when writing this formular.

R. How do you address the challenges you face when teaching Biology lessons on respiration?

T1 I try to give the work to compensate the equations as most learners always confuse the equations.

R. How do you teach practical activities to make the teaching of Biology lessons on respiration more understandable to the learners?

T1 I used the exercise (for aerobic/anaerobic in musles) and making a dough for anaerobic in yeast.

Appendix 2: Acknowledgement to conduct research

P/BAG"
Khori
xas
TEL 067
FAX") 7

Enq:_

14 November 2014

To Whom It May Concern

This serves to testify that **Ms. L. Amutenya** visit our school to do her research for the studies she is currently busy with.

We were please to have her at our school.

Yours

[redacted]
PRINCIPAL

2014 -11- 1 4

Responses from the participants June 2014 (interview questions culminated into a form of a questionnaire)

(a) RQ: How do you introduce your lessons during Biology teaching of respiration topic?

T1: In my teaching of this topic: Respiration, I always integrates it with Respiratory system chapter whereby I refer learners to organs such as lungs that supply oxygen to cells for respiration.

T2: I ask them the following questions: (a) Where do we get our energy from? (b) What is the formular for photosynthesis? and (c) Why do we need carbonhydrates?

(b) RQ: What are your views and experiences on taking into consideration of learners' prior everyday knowledge when teaching the topic on respiration?

T1: In my view, teaching this topic with learners who have prior knowledge tend to understand the lesson far more better than those who do not have any ideas. Those with prior knowledge live to participate freely than their peers.

T2: It's important as learners understand this topic better if they build on what they know.

(c) RQ: How do you make use of learners' everyday life experiences in your teaching of the topic on respiration?

T1: I always ask learners to think how they end up walking from home to classes, what or where they got energy to move around or carry out various activities, hence learners should be aware that the energy they use is obtained through from respiration when glucose is broken down in cells.

T2: I ask learners to run at least 3 rounds as they will know that when they exercise they use up energy, they require oxygen and some can even get a feeling of anaerobic respiration.

R: In what ways do you help your learners to make sense of the topic on respiration?

T1: By giving and demonstrating simple example which is very well known by each learner such as similarities between respiration and burning the only difference is no flames in respiration but both require a fuel and oxygen both release energy and waste products.

T2 : I make sure they know the definition, the formular and why they need respiration by telling them an example of an athlete when they run they breath faster, or some fainting due to lactic acid.

R: What teaching strategies do you use to help learners understand concept on respiration?

T1: I group learners in groups of four, and each group will get a task to tackle and report back, therefore, I have to work hand in hand with each group and give assistance where necessary and then provide a feedback to the entire class.

T2: I give them questions to answer then I can come up with a way to help them depending on what they already Learner centered, where understand.

(a)R: What are some of the key challenges you face during teaching and learning of Biology lessons on respiration and its concepts?

T1: Lack of advanced model or posters portraying the real pictures and parts of organs and tissues involved in respiration real objects to demonstrate to learners what they have learnt in theory.

T2: Chemical equation of anaerobic respiration the equations of anaerobic respiration as learner always get confused when writing this formular.

(a) R: How do you address the challenges you face when teaching Biology lessons on respiration?

T1: I normally try to search and read more various books and google on the internet to enrich myself with the required knowledge towards the topic. I also contact other colleagues who might understand the topic far more better than myself.

T2: I try to give work to compensate the equations as most learners always confuse the equations. I use the exercise (for aerobic/anaerobic in muscles) and making a dough for anaerobic in yeast.

Appendix 3E: Follow up interview Transcript Teacher 2 (see attachments)

1. RQ1: What are your teaching qualifications and please give the name of the institution (s) where it 2.was obtained?

3. RQR: She is a holder of a Bachelor Degree in Education, obtained from the University of Namibia.

4. RQ2: How long you have been teaching Biology at grade 11 level?

5. RQR: She taught Biology at grade 11-12 level for four years now.

6. RQ3: Any other subject do you teach apart from Biology?

7. RQR: She teaches Geography, Development Studies, and Biology grades 11-12 as well as Life Science 8. Grade 10.

9. RQ4: Generally, how long you have been a teacher?

10. RQR: Generally she has 4 years' experience in teaching Biology. She was firstly employed at 11.Pendukeni Iivula Iitana Secondary in 2011 for three months. In the same year, she also relieved for 12.three months at Okalongo Secondary School for Biology and Physical Science grades 11-12.

13. RQ5: What is your area of specialization?

14. RQR: Teacher 2 specialized in Biology and Physical Education grades 11-12.

15. RQ6: Any professional development you are engaged in?

16. RQR: Currently she is not involved in any further study or any other professional development but 17.she is interested to do her Master Degree in Environmental Science in Education.

18. RQ7: Do you use examiners' reports, if so how do you use them?

19. RQR: She do use Examiners' report for revision purpose because they have comments noted from 20. the previous answer scripts of learners and it also reveal errors that do not need to be repeated again.

21. RQ8: How do you use learners' everyday knowledge in your teaching of respiration?

22. RQR: As stated already, I use it to assess the level of learners' understanding on the topic before I 23. give them new information.

24. RQ9: Can you give examples of learners' prior everyday knowledge you can use in teaching 25.respiration?

26. RQR: For example, where do they get their energy from and how do they use energy for?

27. RQ10: Any other comment (s) regarding teaching this topic or Biology in general?

28. RQR: Learners are willing to do experiment's but due to lack of equipment experiments are not being

29.done in Biology. She added that, there are not even workshops conducted to give them information on 30.doing experiments. Furthermore, T2 referred to Paper three (3) a practical paper in

Biology as most 31. difficult to learners as they mostly do theory rather than practical activities. She reiterated that, it is a 32.major problem and it makes them to perform poor in Biology as practical contributes more marks than 33.Paper

Appendix 3F: Follow up interview transcripts for Teacher 1 (see attachments)

Follow up interview Transcripts for Teacher 1 (T1)

RQ1: What are your teaching qualifications and please give the name of the institution (s) where it was obtained?

RQR: She is a holder of Bachelor Degree of Education obtained from the University of Namibia. In addition, she completed a Bachelor Honors Degree with University of South Africa (Unisa) specialized in Inclusive Education.

RQ2: How long you have been teaching Biology at Grade 11 level?

RQR: She taught for 8 years.

RQ3: Any other subject do you teach apart from Biology?

RQR: She do teach Life science grade 10 and she teaches Life science and Biology to part-time students, employed by Namibia College of Open Learning (NAMCOL) since, 2008 and 2010 respectively.

RQ4: Generally, how long you have been a teacher?

RQR: She has teaching experience of 8 years and 7 months now. She taught grades 3 for three months at Oniiwe Primary School in Oshikoto region. In the same year she was given another offer to teach grade 5 at Olukonda Primary School. She then went for further study at the University of Namibia and she obtained her Degree in 2008. In 2007 she was temporarily employed at Wellness Secondary School in Windhoek where she got her first experience to teach Biology at Grade 11 level.

RQ5: What is your area of specialization?

RQR: She specialized in Geography and Biology. She never taught Geography after completion of the Degree.

RQ6: Any professional development you are engaged in?

RQR: At the time of this research, Teacher 1 is not engaged in any professional development but she wishes to register a Master degree in Inclusive Education.

RQ7: Do you use examiners' reports, if so how do you use them?

RQR: Teacher 1said: I use examiners' reports together with the learners while revising the questions papers of that year. She uses to emphasize on scientific errors so that mistakes cannot be repeated. She is also a national marker for Biology Ordinal level, which is an added bonus to her assessment and teaching experience of the subject.

RQ8: How do you use learners' everyday knowledge in your teaching of respiration?

RQR: I asks learners the definition of terms learned in the previous grades. For example, learners know about yeast used in bread baking and know that it is a living organism though some do not know it. From that point, then I have to explain the rest of the class.

RQ9: Can you give examples of learners' prior everyday knowledge you can use in teaching respiration?

RQR: For instances asking learners where do they get energy the next morning to go to school, assume no breakfast was taken since you lastly ate during the night?

RQ10: Any other comment regarding teaching this topic or Biology in general?

RQR: Generally, learners like Biology, but lack of practical materials, chemical reagents can have also effects on the results. Additionally, learners do well in tests, but during the end of year examination in grade 12 the results are not good.

Follow up RQ: What do you think have caused this gap on achievement of the school and that of National level and what could be the resolution?

RQR: Teacher 1 said: I to give standard test and also very strict when marking tests for example, making sure that learners are spelling words correctly and be consistent with scientific words. She added that, more writing activities in their books and on the board should be given. She also suggested the idea of going through learners' summaries and see if learners are writing words correctly as provided. Moreover, T1expatiated further and went on to say, I also provide the notes because learners may not know what exactly to write if notes are not prepared. She concluded that, most important teachers need to know their learners and do what works best for their learners.

APPENDIX 4A: LESSON PLAN FOR TEACHER 1

LESSON PREPARATION

GRADE: 11 A **DATE:** 09. 07. 14

TEACHER: **TIME:**

SUBJECT: Biology

THEME AND TOPIC: Respiration.

TEACHING AIDS AND RESOURCES TO BE USED: Chalk, Chalkboard & Textbooks.

LEARNING OBJECTIVES: Learners will: Know that aerobic respiration yields a lot of energy in the presence of oxygen.

BASIC COMPETENCIES (Refer to Syllabus) Learners should be able to: State the balanced equation for aerobic respiration, in muscles and yeast. as well as for anaerobic respiration

PRESENTATION OF THE LESSON:

1. Monitoring of homework done:

2. An appropriate short introduction (linked to the learners' knowledge and experience): Teacher firstly to ask learners to define respiration using their prior knowledges and also to state the 2 types of respiration.

3. Presentation of subject content and learning activities (including the chalk board summary):

Teacher's Activities	Learners' Activities
- Teacher define respiration as stated in the syllabus. - Teacher will then discuss that A. respiration means respiration with O2 while anaerobic resp. is without O2 - To state the balance equation for both aerobic and anaerobic respirations. - Teacher will also ask learners to name & describe the uses of energy in human body.	- Should know respiration of energy from food substances in all living cells. - To understand that in aerobic resp. large amount of energy is released whereas in anaerobic resp. less energy is released and glucose is not completely broken down. - Learners are expected to know these equations both in words & symbols. - Should know that energy is needed for muscles contraction, chemical reactions, for growth & tissue repairs.

4. Consolidation of the lesson: Teacher sum-up the lesson indicating every living cell uses respiration to release energy all of the time. Energy is needed for all the chemical reactions in the body.

ASSESSMENT /HOMEWORK/ TASKS/EXERCISES

Learners will be given a task to explain how lactic acid is produced and how it is removed using the oxygen debt.

ENGLISH ACROSS THE CURRICULUM:

Reading activities: Learners will be engaged in reading in order to improve their reading skills.

Writing activities: Given a written task to complete, learners writing skills will be promoted.

DEVELOPMENT OF THE NUMERACY SKILLS OF LEARNERS DURING THE LESSON:

By balancing the symbol equations for both aerobic and anaerobic respirations, learners numeracy skills can be enhanced.

DEVELOPMENT OF LIEFE SKILLS DURING THE LESSON:

Teacher to encourage learners to read beyond the summary and visit different sources for betterness of subject knowledge.

COMPESATORY TEACHING/LEARNING SUPPORT TO LEARNERS:

Learning support to be offered to learners with milder learning problems towards the content under learning discussion.

REFLECTIONS:

To be done after the lesson presentation.

Signed by the teacher

Monitored: Principal/HOD/Subject Head

APPENDIX 4B: LESSON PLAN FOR TEACHER 2

Lesson Preparation Form:

Teacher:	**Grade:** 11	**Date:** 25 July 2014. **Time:**

Subject: Biology

Theme and Topic: Respiration

Teaching Materials and Resources to be used:

- Text book
- Chalkboard

Lesson Objectives: Learners will:

Realise that cell respiration is needed for the release of energy in all living organisms.

Basic Competencies/Specific Objectives (Refer to Syllabus): Learners should be able to:

- Define respiration as the release of energy from food substance in all living cells
- Define aerobic respiration and anaerobic respiration
- Balance equation for aerobic respiration and in words.
- State the Balance equation for anaerobic respiration in muscles and yeast

Presentation of the lesson:

1. Monitoring of Homework:

None

2. An appropriate short Introduction:

Why do respiration needed for life

3. Presentation of Subject Matter and Learning Activities:

Teacher's Activities	Learners' Activities
- Define respiration both aerobic and anaerobic	- participate actively - Listern tentively - Ask questions
- State the word equation and chemical equation for both aerobic and anaerobic	- Do the practical on yeast in bread making

4. Consolidation: [redacted]

- Aerobic - glucose + oxygen
anaerobic - glucose ⊖ of oxygen. [redacted]

5. Assessment/Homework/Tasks/Exercises/Classwork:

Practical

English Across the Curriculum:

Reading Activities:

Reading through the instruction of the practical

Writing Activities:

-Record their observation

Compensatory Teaching:

None

Numerical Skills:

~~None~~ 118 KJ for anaerobic respiration

Reflections:

learning objective were achieved.

Summary/Notes:

Appendix 5A-5D: Observation Transcript (see attachments)
APPENDIX 5A: LO1T1

Lesson observation 1: Teacher 1 School 1 (LO1T1S1) Date: 9 July 2014

Topic: Respiration

Duration: 40 minutes

T1: Morning!
Lrns: (chorus) Morning!
T1: We can summarize just to round up the previous lesson. What did we learned? Mbambo (pseudonym), you were not here yesterday, where were you?
L1: Types of white blood cells.
T1: We did not hear!

L1: Types of white blood cells, the phagocyte and lymphocytes.

T1: Sorry!

Lrns: (chorus) We talk about types of blood cells: The phagocytes and lymphocytes.

T1: Aahaa, the phagocytes and lymphocyte…the function of each, you can still remember the function of each? ….even the roles played in the body by each cell, Mbasa (pseudonym)!

L2: Phagocytes engulf and destroy bacteria, lymphocyte…..antibodies to kill antigens.

T1: The function of lymphocyte is to engulf and destroy and kill pathogens, bacteria. Antigens, they are..? What are they, antigens?

L3: Are chemicals that live by pathogens or germs.

T1: Mmmhh, thank you, are chemicals that live by pathogens or germs.

L4: Rise up his hand.

T1: Mmhh, you have something to tell us?

L4: The activities we did, it was like the phagocytes, the lymphocytes produce antibodies and they are even specific…

T1: You are just talking to the meme next to you, people we should not waste time. It's just activity we did yesterday. Every time you leave behind this class, I am just complaining about you. You people have more resources textbooks, excellent, modules. Other schools do not have these books like you. That's why you behave the way you are. You don't even appreciate the subject. You are still the same people who cannot give me answers. Alright people that is enough for now. Today, we are talking about respiration. As far as from grade 8 we has been talking about respiration. When you talk of respiration, is a chemical process. What is expected of you when we are talking about respiration? Mbasa (pseudonym)!

L5: We are expected to learn about aerobic and anaerobic respiration.

T1: In other words: types of respiration in living organisms. Is that all, Percy (pseudonym)?

L6: We are expected to know equations for aerobic and anaerobic respiration.

T1: Oh….thank you!

L7: Equation for respiration!

T1: So in words or chemical symbols, Lempi?

L8: All is already said.

L9: Only takes place in living animals!

T1: Only where? Is that true? Before we go to Kathy (pseudonym), why only in living organism, yes you have ideas but you suppose to say is only living organisms has living cells.

L10: Living cells. Lactic acid and how it is produced.

L11: Give a different between breathing and respiration.

T1: So what?

L11: Breathing also included in inhalation and exhalation. There is no relationship between breathing and respiration

T1: Why do you need to talk about breathing if there is not relationship? For respiration to take place, glucose and oxygen is needed.

L12: Because respiratory system also includes respiration.

T1: Yes, I got your point but for the fact that you are denying that there is no relationship between breathing and respiration, how it become like contradicting.
For respiration to take place glucose and oxygen is needed. Oxygen go straight to the lungs.

Definition of respiration: the releases of energy from food substances in all living cells. That is how you need to know it, likes it or not. Stick to the definition in the textbook. (Long pause) uses of energy, no the types of respiration: aerobic and anaerobic respiration. Anyone with the ideas?
L13: Is the release of relatively large amount of energy
T1: Other one, if we are to compare the two?
L14: Is the release of small amount of energy without oxygen.
T1: First is the definition and the different between the two is the amount of energy. A question may come, why there is a difference in term of energy between the two reactions?
L15: Because of oxygen involvement, in aerobic respiration there is oxygen, while in anaerobic respiration there is no oxygen.
T1: Why anaerobic respiration also release small amount of energy?
L16: During anaerobic respiration, high energy molecules react and oxidized. In the process, this glucose is broken down completely.
T1: The other one could be opposite.
Lrns: Anaerobic respiration, glucose broken down partially.
T1: With anaerobic respiration, glucose is broken down partially or half way. The types of…we did, now the equations. Ok people, sorry before we move to equation, we need to ……….about the organelles. What are the organelles we need to know? What are the examples of these cells?
Lrns: (chorus) Not sure.
L16: Nucleus.
T1: Yes, is one of them.
L17: Ribosomes.
L18: Mitochondria.
T1: In which organelle is respiration takes place?
Lrns: (chorus) Mitochondria!
T1: Let's balance the equation.
Lrns: (chorus), Glucose + Oxygen $\longrightarrow$ Carbon dioxide + Water + Energy
T1**:** What does the arrow means?
Lrns: Speaking softly.
T1: Yeee? People find the meaning of arrow is not only in Biology is very kind of reaction you need to know that the arrow mean….what does that supposed to tell you? Yeee?
Lrns: Talking together softly.
T1: Yee?
L1: Maybe is it not the..?
T1: I do not know, I am asking do not ask me again. Form what?
Lrns: a product (few learners talking).
T1: Mmhhuuu, respiration or sunlight?
Lrns: Mmhhhh (when the teacher talks about something that they did not say).
T1: Alright people, what are the products?
Lrns: (chorus) carbon dioxide!
T1: Carbon dioxide plus?
Lrns: (chorus) water!

T1: Plus?
Lrns: (chorus) energy!
T1: Plus energy. Now what is very important here is now the chemical.
Lrns: (chorus while the teacher is writing on the board) $C_6H_{12}O_6 \longrightarrow 6CO_2 + 6H_2O +$ Energy
T1: Alright, oxygen normally is found as a diatomic----because ….but somewhere somehow the equation is not balanced, atoms are not balanced, atoms are not balanced. What are we supposed to do? Let us see how many carbon atoms? (Showing on the left side of the equation).
Lrns: We have six.
T1: On the other side?
Lrns: (chorus) One, individual learner (only one).
T1: Mmhhhh, only one. Two in front of the side…….it was somewhere…..
Lrns: Behind.
T1: Now we are in shortage of how many?
Lrns: One (chorus).
T1: For hydrogen now we are in shortage of how many?
Lrns: Five, now how….get those extra five atom for carbon?
L3: Can we put a six?
T1: To put a six, is it in front or behind?
Lrns: (chorus) behind hydrogen.
T1: Now this should be (balancing the equation) twelve (multiplying six by two oxygen atom). It is 6 carbons..?
Lrns: Twelve (chorus)!
T1: Is it six carbons?
Lrns: Yes, Mrs!
T1: Six carbons (showing on the left side of the equation) and six carbon showing on the right side.
Lrns: Yes Mrs (chorus)!
T1: Now we balance the carbons only. We move to thee next letter.
Lrns: Hydrogen (chorus)!
T1: We are having 12 (showing next to hydrogen element) and only two on the other side. Now what must we do?
Lrns: (chorus) There are two hydrogen atoms this side.
T1: Mmm? Hydrogen atoms which side? Two which side?
L3: On this side (showing on the right (at water molecule).
T1: Yes you are saying they are two (showing on water molecule atom at hydrogen) and here they are twelve (showing at left side of the equation). Now we are having a shortage of two again.
L4: We put six there?
T1: Put six where?
Lrns: (chorus) Behind hydrogen.
T1: And now, we are not having six now but eight.
Lrns: Quiet.

T1: Six times two is equal to ….
Lrns: (chorus) Twelve!
T1: Good! Six times two (6X2) is equal to twelve, now with hydrogen is also…
Lrns: (chorus) Balance.
T1: Then we move to oxygen.
Lrns: (chorus) Eight.
T1: And on the other side?
Lrns: Giving different answers (they are eight, two, six).
T1: This one (showing six oxygen atom in glucose molecule) plus (showing six).
Lrns: Yes (chorus).
T1: Then we are only having eight,…..
L5: Six.
T1: Where? Here?
Lrns: six plus……
T1: This is four plus ……
L6: Six..
T1: Equal to …..
Lrns: Eight (chorus)!
T1: That is how you have to balance the equation. Thank you very much……..inside the equation. If they are not balanced, you need to do something in order to make sure both sides have equal number of this…..
L5: At six oxygen atom ($6O_2$ there supposed to have a number under …
T1: Six O2, $6O_2$?
L4: Ahaa.
T1: Here?
Lrns: No (chorus)!
T1: Here (showing on the left side).
L5: Now Mrs, Mrs six plus two equal to twelve but here in this book, my dear look there,…
T1: We are not adding!
L5: My dear look there, (showing the equation in the excellent book).
T1: Then it's wrong my dear, if we put a two here……..it will be no longer balanced.
Lrns: talking together in their groups arguing and comparing about the different structures of equations in the excellent, the modules and the text of Biology by Mackean.
T1: You get the same amount but they are talking about oxygen.
Lrns: talking together softly (I missed out what they were talking about).
T1: People, now we are talking about six O_2 ($6O_2$) and we have O six (O_6), now I ask you to identify which molecule……..
Lrns: (chorus) O_2.
T1: O_2?
Lrns: Talking together (missed out).
T1: Mmhh, that's why you keep on telling you that, people the books are written by human being like me and you. And like the excellent is one of the books full of mistakes. So the correct symbol here is O_2 whether you are getting the same number. So what you have to do

is,….the moment you change it to something else, that will be no longer……… Remember we have O_3 representing what?

T1: In the living cell, where respiration is taking place, in the living cell? Now the cleaver learner will still go up to the point of saying in the cell. Now the question is already saying state the organ use in the living cell where respiration is taking place? In the living cell, now what is that?

Lrns: (chorus) Mmhhh, laughing.

T1: You don’t need to say in the living cell but in the mitochondria.

Lrns: repeating the teacher (chorus), in the mitochondria.

APPENDIX 5B: LO2T1 (DOUBLE PERIODS)

Lesson observation 2 &3: Teacher 1, School 1 (LO2 & 3T1S1)

Date: 11 July 2014 **Duration: 80 minutes**

Topic: Role of anaerobic respiration in brewing and bread making.

T1**:** We continue with respiration, but now focusing on the role of anaerobic respiration in brewing and bread making. What did you learned yesterday?

L1: About definition of respiration.

T1: Mmhh, Ok. Alcohol is also needed in our body at least you need a glass of wine as long as you are not over doing it. Boys when taking three a lady can take only one due to their masculinity, otherwise… It is now breaking down this sugar in order to respire, mmhh once it respire always we know now, with every respiration there are substances produced, those are……

Lrns: Carbon dioxide (chorus).

T1: Carbon dioxide being one of them, carbon dioxide being one of them. We have water, for example, mmh, then we are now going to focus on the carbon dioxide. Now what is now the role of this carbon dioxide produced by the yeast in this dough? The (repeating) carbon dioxide causes the dough, the dough, not the bread the dough to rise. One now is rise what will happen?

Lrns: (chorus) Light!

T1: It will become lighter, very good. Once it become lighter, the moment this dough is now being baked, then is also giving a …

Lrns: (chorus) Nice taste.

T1: MMh, nice taste and then you enjoy the bread, last time we talked about if the bread has to be order the dough has to be baked while it's not ready what will happen to it? The quality of the bread its now going to be something heavy and then also is like under cooked and then the moment you eat it with that kind of heavy condition without being lighter, it bring the tummy kind of feeling like bloating. The tummy is now becoming like a bit bigger. It is like discomfort. Until then you kind of…..

Lrns: (all) Laughing.

T1: Mmmhh, while air is now in the tummy carbon dioxide is now are under cooked or partially. Now you have …it means that the if processes was not complete what will happen if you eat the bread, the process might continue within your tummy and then this carbon dioxide inside supporting to rise the dough, is now rising the tummy.

Lrns: (all) Laughing.

T1: So it is also one thing that we are telling that after you eat that bread, there is now that carbon dioxide causing air in the tummy and you feel like some kind of discomfort. Until such a time the process will become complete for the tummy to come to normal.

L3: Pumping (laughing) or will it be just like that?

T1: They are saying that if you will moos becoming like bloating that bloating……The tummy will have now a lot of air. Respiration is now taking place. Now we know that respiration normally takes place in those three organs: the lungs, the skin and the kidney. Does excretion take place in the……

Excretion obvious we know in our body……

Lrns: No (chorus).

T1: Excretion obvious which is we know in our body is only take place only in those three parts. Hence, the…….are not part of the excretion before they were never before in the cells. Respiration only to do with the substances produced in the cell during cellular respiration.. Where else…cannot even fit there.

L3: What happen if I eat yeast?

T1: If you happen to eat this yeast as you are saying bloating will come in. In most cases bloating will come with any type of food substance, some people when they eat they eat for example, even some times is the pumpkin, depends to individual person. Some times after you eat the pumpkin you feel the tummy is going up. And then after a while…….

Lrns: Mmhhhh.

T1: After then you pump out are out you feel like then better and better until is finished. It might be like that we don't see the tummy going burst. The tummy is made up of flexible muscles which can expand, which can expand until the tummy can go forward but not bursting. Alright people, now we need to understand that are… the role of brewing and bread making and also these processes of respiration and main reasons of these are to breakdown sugar which is now present in the bread, dough of flour. Obviously you have to add flour, add sugar and the sugar will be broken down by the yeast when it is respiring. And then after that Carbon dioxide have to be used and remember there is always energy which is being present here, and the same time this yeast are breaking down this sugar. Suppose also alcohol is to be produced, even there bread making alcohol is being produced but with the bread, alcohol only disappear the moment you put your….Even it was baked with extremely temperature. Alcohol was produced during fermentation it has to evaporate because of the high temperature and then once this happen, you don't have alcohol present in the bread, but with alcohol, fermentation alcohol will remain if there is no burning for alcohol to evaporate.

L5; Out of the bread or out of the liquid?

T1: Now is that book they are talking about yeast?

L4: Now mrs,……the yeast reacting with sugar…..acohol…If we bake what will happen?

T1: What are you saying again?

L4: The yeast if react with sugar, now when you bake what happen to gluton?

T1: I don't know. What is gluton? Is it an enzyme or what ? I thought you are talking about
enzyme. I don't know you can go further.

L4: Is a protein….it produces an enzyme..then when the gluton…

T1: What is gluton? Is it a substance or a protein?

L4: Is a product, is a product, an end product of catalyzation of sugar..

T1: Yee, ok. A product of ……

L4: Catalization

T1: Now, I don't know. Is it a product or a dough itself? No. it…on a bread. It is a protein
again? Mmmhhh and then you also need to remember that after exposing the enzyme to
extreme hot temperature, what will happen? What will happen to the enzyme?

Lrns: (chorus) Denature!

T1: Denature, denature….

L6: When you put a lot of yeast in the dough what will happen?

T1: A lot of whata? Did I say put a lot?

L6: No mrs, I am saying if you put a lot of yeast?

T1: Why do you have to put a lot? Are you not conservative enough?

L6: I don't mean like that?

T1: If you have too much it will also increase the reaction but if is too less the reaction will
go down.

L6: Since you bake the bread, if you put too much it will have that funny taste.

T1: MMmhh, yee, now?

L6: Mmmhh

T1: Now, Now what is your conclusion? People you ask things that you have answers and
experienced yourself. You suppose to tell me and you have also reasons behind because if
you ask me things that you experimented, I did not do the experiment. You suppose to tell
me that what I have do aa..I have done this type of experiment whereby I tried to bake a cake

with a large amount of yeast and there with an over amount of and there was a different taste and smell. I think the difference become because of in this cake there was this quantity and the other one was this kind of quantity. Now every time you just ask, now what is your suggestion? Because you are the person who went on the field to do the experiment, it was not me, you know what you did, Kaapa (Pseudonym).

L6: Mmmhhhh.

T1: Yees, people you don't expect teacher to say, you must also tell us what you are, what are your suggestion, then if we are maybe not proving your answer, then we can come in that aaa-aa, I don't think that's what will happen, but this could be that….now what is your…

L7: Is it true that when you….alcohol ….alcohol will evaporate?

T1: UUmmhhh, the role of alcohol…..not all the alcohol is evaporate some of the alcohol remains and then it makes you to get drug.

Lrns: Nooo.

T1: Yes, because it was…in the food, obviously you have to become drug if you consume too much of it.

Lrns: Quiet.

T1: Why are you saying it seems not all the acohol have evaporated?

L6: Because of the smell and the taste.

T1: Who said that is alcohol? How do you know that that smell is for alcohol? May be from the yeast itself?

Lrns: UUUhhh mrs (chorus)!

T1: People you state things that….without approval of that. If it is alcohol then you say ooh, ok because in most cases there are no like wrong question or correct question when it comes to this types of…you will just ….these are just like kind of assumptions you assume there might be alcohol still present.

L4: …(.Missed out).

T1: How did you….are we really eating …..I am just asking. You have to extr….like to ten to twenty spoons? Then remember if it has to do with quantity not just the moment you taste then you get drug, unless you are a chicken.

Lrns: Waa haha (chorus)!

T1: Mmmh, yes, that is means for example one glass, if you are taking one glass of wine for example. If you now just taste, then obviously you start….

Lrns: Get drug (chorus)!

T1: It has to do with quantity people we also talked abouta that even when we were talking about hygiene when we said when we talked about diseases we said even if we said it doesn't mean if we are not sick today or tomorrow, hey! If we are not sick even right now it doesn't mean we are hundrend precent free from pathogens? Are we?

Lrns: (chorus) Noo!

T1: No! Somewhere somehow in our bodies we have, we are carrying these germs, but we are not getting sick. Why? Because they are not in large quantities to cause diseases. This is similar, you are tasting something which contain alcohol but it doesn't mean that the moment you take that sample into your mouth or body then you start getting drug. How will you say that the thing is not causing you to drug because the quantity you consume is not strong enough to make you drug.

MMMhh alright people can I just read quickly under the brewing here what they are saying. They are saying are…brewing and bread making using microorganism by now we know what are microorganism, can respire successfully without oxygen then, yeast can respire with or without oxygen. MMh, when it respires without oxygen, that is anaerobic al respiration….fermentation where by this glucose….acohol plus this carbon dioxide and some energy. Mmmh yeast is used in brewing and bread making, both of them they require yeast because….can respire. In the absence or presence of oxygen…water what what….they are source of sugar they are source of the sugar. In the process called maltose…these grapes are allowed to germinate for a few days. During this time enzyme breaks down the starch in the in the grain. Enzyme break down the starch which is now present in the grain into a sugar called maltose. You know, starch even there…starch is broken down into maltose, before converted to glucose. Maltose is the disaccharide sugar, this sugar is dissolved in water, so to give a brown liquid called…..that is….let see the process of …..this is added to the…and fermentation take place to give bear and characteristic. Even this kind of drink contain carbon dioxide, even the Vigo thing which is special nowdays that the are selling. The flour, this flour the flour of the …added, the flour the taste not the the powder, the flour are added apparently. This are…from the …plant. Alright, this is moose on brewed industrial…just additional information. Brewing also used in computer technology to carefully monitor and adjust condition…Is like those big thing where they normally, the beer are now being fermented and they will be taken out into bottles.

Lrns: (all) Mmmhh.

T1: People, that is lastly what they are saying here, about the brewing. What you need to understand is just the grain …and enzyme are coming in to break into maltose and then maltose will be or the (long pause) yeast will be added to this…and on the yeast is added, then the the respiration come in consisting what? Alcohol, mmhh, alcohol and carbon dioxide and then in other book they are saying is that now, is that carborn….that thick thing kind of ..aaa..or this marble, those marble in this kind of are now caused by carbon dioxide produced during respiration of ..hence, we are taking in that carbon dioxide, the moment we are drinking that marble.

….kind of drink contain this carbon dioxide, even the vigo thing ..nowdays they are selling the moment you open…there is always bubbles they also contain carbon dioxide(long pause) searching information in the book.

Lrns: (all) MMhhh.

T1: Here they are saying they are produced using yeast for example yeast is produced using grains…yeast …give alcohol. Traditional Africa bear are mixed mostly from soghum and maize. Yeast convert sugar in this grain to alcohol. ………………………………………caused by carbon dioxide which is also produced by alcohol fermentation.

L4: No mrs.

T1: They also said we can also use this to make bread, I am coming (while continue reading in the book), when salt and sugar are mixed with sugar and yeast, the yeast breakdown the sugar in the process called alcoholic fermentation meaning that similar way carbon dioxide can add alcohol, the carbon dioxide that is present …to rise and then taking the dough until….remember there are….they are not….and one thing the the theee baking the dough……or baking or baking bread, baking bread are …using yeast…mmmhh….

L8: ….missed out.

T1: Ahaa, let's just round up with this bread making. Baking is another example of…to help produce the food. Bread is made up of dough a mixture of flour, water, sugar and …..This mixture is put on a warm temperature, yeast ferment the sugar producing carbon dioxide and alcohol…Alcohol in the bread making ..inside of the dough and they rise the dough, when a bread is baked in a hot oven the bubbles in bread making the bread rise and getting lighter. The yeast causes alcohol to evaporate leaving behind the original of bread. I don't know the assumption that you are saying if you put too much yeast in the dough then some of the alcohol are not going to evaporate. Yeee?

L4: The alcohol will evaporate.

T1: Yees, because the evaporation always takes place with what? If there alcohol is now being boiled obviously will form a water vapour and then start to escape leaving the bread behind without any alcohol. I don't know how some of you, you have eaten under cooked food bread…which make you drug.

Lrns: (all) mmmhhh.

T1: Mhhhh, Kapaa (Pseudonym)….mmmh, you have your own mouth we need to hear from you also.

L4: (Pointing to the other learner)

T1: Aaa-aa, we don't …that is the…we also need to hear from you. What type of suggestion might also help us….mmmmh, to people in your book on page 203 or 75, page 73, mmhh, on page 75 we are having those 350 per….we also need to discuss briefly , on page on your book 73, we also need to ….

L6: Alright 72-73, ehee, anaerobic…………………………lighter to give taste to the bread so that you can eat it nicely and breath, rather than you eating the one which is like kind of half cooked as you are saying. Now in alcohol which is alcohol fermentation what we are looking for is alcohol. Which is also being produced during this anaerobic respiration of yeast, so what we are looking……aa, aa boiling for example otherwise there alcohol they are looking for evaporation (long pause) to what is going to remain behind at least without any alcohol. Mmhhh (long pause) so any thing again, any thing again maybe not so clear or need again just , just…..mmhh?

Lrns: (all) Quiet!

T1: EEE? Then, this.

L4: ……(missed out).

T1: Eeeh? Nepaya (pseudonym), mmmh, ok if there are not questions see you at school on Monday. Oo, see page 72, 73 these are ….complete the work below by writing the stamen, distinguishing between the aerobic and anaerobic respiration. A lot of energy in..

Lrns: (chorus) aerobic respiration!

T1: A small amount of energy now again, because this one is applicable with the definition….we can see the …in the..now anaerobic respiration and then aerobic respiration…energy so it is an opposite of number two..mmmh the third one?

Lrns: (chorus) Anaerobic respiration.

T1: Anaerobic respiration and carbon dioxide is released, and then anaerobic respiration, yeeh? While we were talking about carbon dioxide rising the dough, now you don't read, you must also read. (Pause) mmhh ok, may be those yeast did not respire, in which….with lactic acid is carbon dioxide produced, because in maltose carbon dioxide is not released like at least whether now is fermentation or alcoholic fermentation of bread making also…producing..

Lrns: (chorus) Carbon dioxide.

T1: But in maltose there is only lactic acid and then less energy. And now in this cake do not respire, this anaerobic respiration we are hearing. Alright then, fourth one of anaerobic respiration, and the fourth one on the other side it takes place on the unicellular plants and maltose for….cellular side. Now what would be or could be the correct answer on number 4 for anaerobic respiration, it takes place in all, taking place in all living cells, in all living cells, so I want you first to do that comparison, comparison in your own, in your summaries.

L8: This?

T1: Yes, that one. Compare aerobic respiration and anaerobic respiration in term of relative amount of energy released but not only in the amount of energy but just give the whole comparison so that you have an idea of the differences between the two. And there is another question that I want you to do, and place it in your note somewhere. Explain why we carry on breathing heavy after we finish exercise of hundred times?

L7: We don't know why?

T1: Write it down in your book. Some of you are holding…Explain why we carry on breathing heavily after we finish …..hard exercise? After we finish exercise of hard …exercise (repeating slowly while learners are writing down in to their summaries). Between aerobic and anaerobic respiration, (long pause) mmmhh, we start with number one. (Long pause) and the other one obviously underlined word is chromosome ….it but small, relatively amount of energy. (Long pause) while learners are taking notes. The third one, oxygen is used then no oxygen used, number three, (long pause) mmmh, another one?

L9: The…of carbon dioxide.

T1: Carbon dioxide again, glucose completely broken down, and then here partially. Ok you can add that one the production of carbon dioxide but we need…also that there are two, two types of anaerobic respiration remember the one with yeast that one produces carbon dioxide and one in muscles no carbon dioxide. In yeast whether is now alcohol or alcoholic fermentation of bread making, they are both producing carbon dioxide. But another form of anaerobic respiration that is now taking place in the muscles carbon dioxide is not produce but is now a different when it comes to anaerobic respiration. (long pause) and we just need to ….

L11: Like in anaerobic respiration…..

T1: Where did they say that in your module? Aaaa..

L11: Like….

T1: Mmhh?

L11: Aerobic respiration is like…

T1: Like what?

L11: Is like….Now even there are…

T1: I have been also informing you people that we teach according to the syllabus' basic competencies of your level, remember November we are having two examination levels. It does n't mean everything in the book is your level. I told you that the gray part normally is high level. What I did here if I have to take you back to respiration, I told you already from the beginning that we only need to know the definition of respiration itself, the two types of respiration: aerobic and anaerobic respiration, the definition, the equation in words and symbols for all these types of respiration , aerobic and anaerobic respiration and then the role of anaerobic respiration in brewing that is the one we discussed now as well as in bread making and then the production of lactic acid in muscles during exercise, that's what we wrote on the summary there. Again the comparison between aerobic respiration and anaerobic respiration that is exactly what you have. What is missing for this syllabus, nothing. So, so we don't follow what is in the textbook we follow what is in the syllabus. People are assessing you according to the national guidance of the syllabus. Don't stressing yourself to read beyond your level and then you will end up wasting your time. If you were having higher level, then I understand then we would continue with that…

L4: When are we choosing higher level?

T1: Mmh, who said you are the one to choose? May be its me to choose you.

L7: Aaau!

T1: MMmh, teachers are choosing according to the potential of learners, you cannot just come to me and say you want to do high level while in your performance such in Biology lesson or test you never completed any. You are just there, like empty vessel, no come higher level you want to join so that you can give me a big U.

Lrns: (chorus) Laughing.

T1: Now people we don't have higher level at our school, it have to be approved by the region and accepted and the problem ….we most….in Biology…..We don't even have a proper lab, for higher level learner, when it come to the practical paper you have to go there assemble a certain kind of apparatus , we talk about a photometer, you should be able to sept up a photometer that's now during the examination, and none of any one coming to assist you and if you don't know how to assemble it you get a zero, with that specific question.

Lrns: (all) Mmmhhh.

T1: Alright guys, but there is an activity you did not complete, complete now activity seven, as well as now….and again the…those are the activities you need to bring on Monday. And also you go through also respiratory system in human where they are talking about gaseous exchange and so on. We are now going to different between breathing and composition for air between inspired and expired air, depending on percentage of …..oxygen. We are now going to start with respiratory system in human whoever is not yet done with this portion , remember you have to go along your books I will not teach this anymore, even you, you have time to rise up problem…..come Monday, we go straight with the respiratory system. People we are behind, we supposed to start with excretion ..to that come next term we are start with coordination and sensory. Because sometimes I remember is like that time, we were already finish with coordination but this time I don't know whether we are going to make it …..alright….

APPENDIX 5C

School 2, Lesson 1 **Date: 22 July 2014**

Subject: Biology **Duration: 40 minutes**

Topic: Circulatory system and pulse rate

T2: Morning class?

Lrns (chorus): Morning madam!

T2: Yesterday we learned about the heart? How many chambers in the heart?

L1: Four

T2: They are four; if they are four give me one?

L2: artria, ventricle.

T2: Atria plural, atrum singular. So that is what we discussed last time. We also talked about three types of values, Mafuma! Give me one type of value that we discussed.

Lrns: No response.

T2: You are not in class.

L3: pulmonary value (another learner responded).

T2: other one?

L4: Bicuspid value.

T2: I told you before, so inside the heart where are they located? For instance, semilunar value between right atrium and right ventricle and then tricuspid between right atrium and left ventricle. How do we call the blood vessels that are associated with heart, liver and body? Kati (pseudonym), how do we call blood vessel that transport blood from lungs to the heart? Heee, how do we call it, Dax (pseudonym)?

L5: Pulmonary vein.

T2: How do we call the one that transport blood from body tissues to the heart muscle? How do we call it?

Lrns: no response.

T2: How do call the one that transport blood from body tissues to the heart?

L6: Vena cover.

T2: From the heart to the lungs?

L4: Pulmonary artery.

T2: That is what we discussed last time. So that build on what we are going to talk today. We are going to talk about the pulse, and later blood vessels. On page 48, there is a definition of a pulse. On page 48 they are saying that is a way of blood flowing at high pressure.

Lrns: Mrs on the module or excellent?

T2: Excellent on page 36. In excellent they are saying is a way of …now the artery it pushes blood vessel to expand and it becomes larger. As the blood is flowing for instance here (pointing the blood vessels below the palm) there is expansion inside because the blood vessel is expanding so that expansion, that way expansion because there are ………..You can only feel it if you press the artery against the bones. Whenever the blood is pressing the blood vessels that expansion, so that is what we call the pulse and the pulse you can only feel it if you press the artery against the bones. So press the artery against the bone because I want you to see that. Is that movement of blood as this goes into your vein, artery and atrium. It comes in with high pressure. So they are saying is the way of increase of blood pressure or sudden expansion of a point in artery. This occurs as …heart pump blood, blood to left ventricle. We know that the left ventricle, this is the ventricle that pump blood to the rest of the body. When it expands pushes blood out of the heart to the artery through the aorta. So when it comes into the aorta, it comes with higher pressure. So this higher pressure is the one that causes the blood vessels to expand. So that expansion, movement expansion of blood vessels is what we call a pulse.

So I wanted you to feel our pulse before we talked about the effects of exercise on pulse rate. So all of us I want you to take two fingers so…..palm with its own pulse. You can either feel it here (pointing at the blood vessels below the palm) or somewhere here (pointing at blood vessels on the neck below the oesophagus) the start with the palm…..Take two fingers, these two fingers (separating the……..) and press your blood vessels, blood vessels vein against the bone, so (she keep on pressing the veins against the bone demonstrating to the learners on how they should do it).

L4: it is stopping!

T2: So, eee, the what? The heart?

L6: the heart is stopping?

T2: Is the heart not beating?

L4: I do not feel anything.

T2: maybe you are not pressing well. Who feel their pulse?

Lrns: Me! (**different learners saying it together**).

T2: So how does it feel? Heee?

Lrns: the pumping action!

T2: The pumping action, that's how now what we call the pulse. That's how the blood is going ….So I can't see why he cannot feel his pulse.

So how many of you felt your pulse? Some are not doing the right pressing (looking at learners how they are doing it). Press it against the bone hard, so that you will be able to feel the blood pushing like,

L7: Like a…..

T2: Yes, so that blood that goes like a ….. is an indication of how your heart pump blood into your aorta. If you don't feel it its ok but you need to feel that. So now, yeeh…

L5: Mrs, what about here? (pointing on the forehead).

T2: The best place to feel your pulse is only here (pointing the blood vessels below the oesophagus) or here (pointing the blood vessels below the palm on the left hand). So that's the only place where you can able to feel your pulse.

L4: Is pulse the flow of blood?

T2: Noo! The pulse is an indication of how many times that your heart pumps blood to the artery. So, you can only feel your pulse when your left ventricle pump blood to your artery. So as blood is flowing there to the aorta, there is expansion. That expansion as blood is flowing is what we call a pulse.

L5: How do Doctors determine, aaaa, the what?

T2: The blood pressure of patient?

L5: That they are using what is it called?

T2: Ms. Amutenya, how do they call the instrument Doctors are using to determine the pressure of blood? So they are using, how do they call it Ms. Amutenya? The, the one that they are using for Bp, there is a machine the are using to to find out the pressure of the blood.

L5: Pressure pump!

T2: So that one is an indication of how fast the blood is flowing through artery or vein. So what we are saying is that if for instance the artery that is only where blood is flowing to the high pressure because here we do not have valves (missed out where she pointed), they are flowing at high pressure to make use of ……..because here we don't have values to prevent the the back flow of blood even if the person is taller, so the blood vessel carry blood to kidneys go to the reproductive organs so they need, it needs higher pressure so that it can reach there. But now, if you are saying that the pulse is the way of increasing in the blood pressure or sudden expansion in the point in the artery, this occur as the heart stretch to pump blood into the left ventricle so this pulse, this way movement it can be affected by exercise (writing it on the board). What do they mean by exercise, Aaa, Mhhh, can affect the pulse rate? They are saying that that exercise, when you do exercise, it increases the pulse rate. So, Mate (pseudonym), the movement you see the word rate, what does it mean?

L8: The flow of blood.

T2: How many times it flows or that it happens in minute for in an hour or seconds. They are saying that during exercise, you will always increasing your pulse rate, and that is an indication that if you are exercising, you are increasing the rate of how the left ventricle is pumping blood into your aorta. And that thing will also increase pulse rate. So exercise increases pulse rate. So why does pulse rate increases? This is very important to know. Remember, this left ventricle, it pump blood with oxygen, and oxygen is the one that is used for which process?

Lrns: Respiration (**chorus**).

T2: So when you are exercising you are using a lot of oxygen. Let say you are running when you are running, you are using your legs, so if in the legs the energy which is there is being reduced, so therefore your pulse rate will need to increase, to be able to supply blood with enough glucose plus oxygen (writing on the board) for you to be able to release enough energy. So that is the importance of increasing pulse rate during exercise. So it is not a bad thing as when you exercise you are also breathing from left ventricle to pump all blood, with oxygen and glucose. That means that by those organs that take part in exercise, so that you do not lose focus, you do not go for anaerobic respiration but we will talk about it tomorrow, but the good thing is that what you need to know that exercise will always increase your pulse. Why it is important? The main reason is that when you are exercising, you are……and that oxygen you need to be replaced, how can you replace it? You can only replace it if you pump blood with oxygen and glucose in those muscles that is one thing what you need to know. So turn on your book pick up the pulse rate, so the more vigorous is the exercise the fast the pulse. What does vigorous mean?

Lrns: No response.

T2: Yeee?

L4: More fast exercise!

T2: Fast exercise or heavy exercise always causes the pulse rate to increase. The important is that in order to deliver oxygen and glucose to active muscles as quickly as possible to produce energy during respiration that's why……however, even if they are saying that vigorous exercise increases the pulse rate not in everyone. So for instances in this class, we have Kaupumhote (pseudonym) who is fit and Pohamba who is unfit, so what we are saying is that the pulse rate of a fit person does not..

L4: Change much!

T2: Does not change much compare to the person who is unfit. So because if you are not fit the moment…how will you…and you will need more energy compare to the fit person, so the person who is fit their heart use to pump more and more blood at a short but the person who is unfit, their muscles are not that active compare to the person who is fit. So what we are saying here is that the pulse rate of a fit person does not change that much and it goes back to normal pulse rate as quickly as possible unlike for an unfit person, the pulse rate change too much more than the person who fit and it also take the longer period of time to go back to normal pulse rate, so that one you need to know. So the fact that the blood vessels, but before you go to blood vessels you need to know the causes of four heart diseases. So what they are saying is that if you continue doing them or doing them can affect your pulse what are things you need to do in order to prevent these diseases, so number 1) higher cholesterol in the diet. What is cholesterol?

L10: Fat food.

T2: **Food made up of fat**. So if you eat too much fat, food that contains too much fat.

L11: Especial red meat.

T2: Ahaaa! So some of you, you are even drinking that soup that contain too much fat, so what they are saying is that food that come from animals contain too much fat compare to the food that come from plants. If you keep on eating food for instance food, for instance, **eggs,** meat the fat in these ingredients tend to be too higher because animals' food consists of higher cholesterol. So make sure that you avoid too much of that food.

L12: What about eggs?

T2: Eggs also, they contain higher cholesterol because it also come from animals. Then the other one is stress. Some of you are ever stress any simple thing you are already stressed.

L4: Especially me!

T2: Without thinking, Haa, because your girl fiend did not reply an sms, because you don't want to go to school you are stressed, because your girlfriend do not want you anymore because your boyfriend do not want you anymore. What stress do to our circulatory system? So stresses make your heart to pump blood very fast, and that means that one day you will have high blood pressure, hypertension because of higher blood pressure or stress. So what I am advising you to do is that in life is not only you who are going through stress, everybody has their own problem. Why should you, so stress, so you don't need to show that this one is going through stress. No so just learn to solve or deal with own stress for your own good. So these things that you are worrying about some of them are not even important in life. Why should you die of heart attack because of something not important? So make sure you are having enough sleep and you avoid those stressful situation. The third one is cigarette smoking.

L5: Ahaaa, (others: Etoooo while looking at a male learner at the back of the classroom).

T2: Are there some learners who are smoking here? It is better to avoid smoking. Cigarette smoking can cause heart attack or our circulatory system. Please avoid smoking. Number one, cigarette smoke contain carbon dioxide..monoxide, so carbondioxide is one of the components ..so if you keep on smoking, what type of diseases you will have? You are reducing the amount of oxygen flowing in blood.

Lrns: Laughing (in a chorus)!

T2: Remember, oxygen cannot be in a singular form it needs to be is a diatomic molecule, all need to be in a di-form. So at the end, there are also that…cigarette smoke is composition may lead to cloting and we know that if your blood vessels one of them are blocked because of a clot it will lead to a heart attack. Please make sure that you avoid smoking.

L5: Is alcohol fine?

T2: Yeee, alcohol, thank you! Alcohol, they ae saying that alcohol is good for your healthy but…..

L5: Iyaaa..

T2: When we say alcohol.

L5: Thank you mrs!

T2:   When they are talking about alcohol, they are not saying four beers. They are talking about one glass of wine per day. So what they are saying is a glass of red wine.

Lrns: Talking altogether (arguing about the amount of alcohol per day).

T2: Pay attention, they are saying one glass of red wine is important to reduce the amount of stress in your blood vessels. Not the whole glass, not the whole bottle.

Lrns: Aaahh.

T2: Let's continue, with the blood vessels, so you need to know about three types of blood vessels in our blood. So these blood vessels are very important. So if you go to page 49 there are three types of blood vessels that you need to know. So number one we have the..

Lrns: Arteries (**chorus**)!

T2: The arteris, number two?

Lrns: Veins (**chorus**)!

T2: The last one?

Lrns: Capillaries (**chorus**)!

T2: Mhhhuu, capillary. So those are the 3 types of blood vessels you need to know. If you….number one you need to know the number one?

Lrns: The functions (**chorus**)!

T2: Two?

Lrns: Structures (**chorus**)!

T2: Number three the values, for instance example, the presence of values absence of values. So that one you need to know, it is very important. Starting with the function of the artery, there are thing that artery they carry blood.

Lrns: Away from the heart (**chorus**).

T2: From the heart to the body tissue, so all the blood vessels, all the arteries, they should be able to carry blood away from the heart. Then the other one is the types of blood they are carrying.

L5: Oxygenated blood!

T2: Ahaa, we will talk about it later. So the function (drawing a table on the board)

Arteries	Veins	capillaries
Carry blood away from the heart	Carry blood toward the heart	Exchange of substances between the blood and the body tissues.

carrying blood away from the heart so when we say blood away from the heart, for instance the aorta, carry blood from the heart to the lungs. So all of them they should carry blood away from the heart. Going to the vein, they are carrying blood toward the heart, towards the heart when we are saying toward the …we are talking about for instance vena cover carrying blood form the body to the heart or from the lungs, to the heart through pulmonary vein. Then the capillary, this is the connection between the artery and the vein. So the capillary are responsible for the exchange of of substances between the blood and the body tissues. Make sure you know this, so make sure that you know this (repeating). Then for instance, when aorta carries blood form the heart to the rest of the body. So, let say for instance the renal artery, an artery that goes from the aorta to the kidney so then inside the kidney, there are capillaries between the artery and the vein. So the vein are inside for instance in the, in the kidney, so inside the kidneys there will be exchange of substances so which substances are we talking about? For instance things like glucose need to come from the blood to the body tissue. Things like oxygen need to come from blood need to go to body tissue. So now the interaction, between the blood and the boo body tissue all goes to the capillary. So all these substances that fill into through the capillary to the body tissue or from the body tissue into the vein and then can be carried away to the other part of the body so that one you need to know. Then we go to the structure. The structure you need to know the drawings and then the parts of specific blood vessels (while drawing them on the board). Starting with the artery, arteries are made up of.

Lrns: Thick layer of muscles (chorus).

T2: Thick layer of muscles and elastic fibre with the small rumen and then the vein is made up of thin layer of muscles, no elastic fibre, then big rumen or large rumen. The capillary is made up of one layer cell, thin wall.

Lrns: Thick wall!

T2: Thin wall, is a thin wall. So if you look at this, lets first look at drawing. Starting with thick larger and then elastic fibre we are saying that arteries are carry blood away from the heart. we go to the aorta for instance, remember, the aorta is receiving blood from the left ventricle, and this blood with stand higher blood pressure, so for the blood vessels to be able to cater for that high blood pressure, thick muscles so that it cannot burst and also it needs elastic fibre, so remember we talked about the pulse, say the expansion of the blood vessel, so for these blood vessels to expand and go back to their original position. It needs elastic fibre. So that is why arteries have thick muscles and elastic fibre to be able to go back to the normal place when blood is flowing through them. Then small rumen, here blood is flowing at a higher speed, so think about if you have two water pies (drawing the pipes to show their diameters on the chalk board) one is bigger having a large diameter and other is small in diameter. If you are the, the, you are now pumping water through these pipes, which one of them will water come with high speed?

Lrns: One with thin diameter (**in a chorus**)!

T2: Hee, why?

Lrns: They are very small (**talking together**)!

T2: The size is very smaller and water pressure will be higher. So same apply to blood vessels, so the smaller the diameter the higher the…

Lrns: The higher the pressure (**chorus**)!

T2: So same apply to blood vessels. So due to the fact that arteries have small diameter or or small rumen that make it possible for blood to flow at higher speed and then for it to be able to reach the other part of the body in the short period of time. Then we go to the vein, veins are having thin layer of muscles, large rumen and then the other one is value. So thin layer, because blood is flowing here at low speed (showing on the drawing) it does not have high pressure, so they are not at risk of bursting so they don't need thick muscles. Then large rumen as blood is flowing at slow pace, the rumen is big for more blood to flow and for instance here(missed out where she was pointing)….The vena cava is taking taking blood away form the body to the heart. So for the body to ……waste product……..And the last one value, due to the fact that now the blood is flowing at slow pace, slow pace, slow speed, no high pressure, so the vein they have value to prevent the back flow of blood into the vein that is the reason why they are having values. Because their blood is throwing at a very slow pace, that is the main part.

Lrns: mmhhhh (all together).

T2: Flowing at slow pace. Now for the blood to reach wherever its needed, the values are there when blood passes that place (showing the value on the board) they close for blood to go until it reaches the heart or from the lungs to the heart so that it can reaches the heart without flowing back. Then the last one is the capillary. Due to the fact that this is a where substances exchange, they don't need a thicker layer, so that the diffusion will take place as fast as possible…and then thin wall, so there is no contraction, there is no expansion for them they are only there for exchange of substances but ….they also don't have value like artery. The only blood vessel with value is the vein. Any question there?

L5: Where they are found in the body, the capillary?

T2: Where? They are found in body tissue, where? In the muscles, in the heart, in the blood tissue, in your kidneys, they are found all over the body, where the exchange of substances between blood and tissue take place. So there is no a specific place only where they are found. They are found all over the body, so that is something you need to know. Then, the types of blood flowing, just for the last two minutes (when the siren was ringing for the next period). Blood flowing in the artery it got oxygen, oxygenated blood except the pulmona….

Lrns: Pulmonary artery

T2: All the arteries in the body they are supposed to carry oxygen and they are receiving blood form the aorta, however there is pulmonary artery that is carrying deoxygenated blood from the right ventricle to the lungs. So this is the only artery that carries deoxygenated blood. And all the veins in the body they are supposed to carry deoxygenated blood, blood without oxygen, because they are all taking blood to the vena cover so except the pulmonary vein which carries oxygenated blood from the lungs to the heart. Any question there? Any question?

L5: Is the anus having values?

T2: There are sphincter muscles there that are controlling the feaces from falling out.

L5: What is stopping the blood not to flow back?

T2: There are values; values are the ones that stop that. There is no pressure. So blood for it to go there, there should be value, when it comes for instance here (showing on the structure of the heart she have drawn on the board) after the blood passed the vein in the right ventricle to the lungs, the value will be closed for it to go there. Keep that for next week so then tomorrow, we will come to do the respiratory, the respiration. For the blood vessels, we will continue next time for tomorrow we will do the respiration.

L13: Is respiration part of the exams?

T2: No…starting from….to circulatory system.

L4: Thank you mrs.

APPENDIX 5D: LO2 & 3T2 (DOUBLE PERIOD)

Lesson observation 2 & 3: Teacher 2 School 2 (LO2 & 3T2S2)

Subject: Biology Date: 25 July 2014
Topic: Respiration **Lesson duration**: 80 minutes

T2: Good morning class!

Lrns: (all) Morning Mrs.!

T2: You learn about respiration in grade 9, who can still remember, why respiration is important for life? Mpho (pseudonym)!

L1: For cells to obtain energy.

T2: Is it for cells to obtain energy? Other one?

L2: Another learner, answered: is for cells to release energy, to cool down plants.

T2: Is that all?

L3: For exchange of gases.

T2: What else, Mate (pseudonym)?

Lrns: (all) Quiet

T2: So, do plants respire also or are only in animals?

L4: Animals. (others) both!

T2: Where does it take place exactly?

L5: In animals only.

T2: Who said only in animals? Why in animals only?

L5: Is it a question?

T2: yes. The question is, if is only in animals but not in plants? Why you are saying so? you must have a reason for that.

L6: Living organisms

T2: You learn about seven characteristics of living organisms and respiration is one of the characteristics of and if you say only in animals, you exclude plants. So far we talk about nutrition, growth, and is also characteristic of living organisms.

L7: Protection.

T2: Those other things will come later. Today we will only talk about respiration. Who can define the term respiration? What is respiration?

Lrns: (all) Quiet

T2: Is the release of energy from food substances. Remember, energy is never produced only releases and converted from one form to another. Therefore, respiration takes place both in plants and animals. Simple, because all of them are living organisms. We have two types or forms of respiration: aerobic and anaerobic respiration. For each of the two types, you need to know the following: number one (1), the definition and number two (2), the formula.

L7: Page 62

T2: Whenever respiration is taking place…………which food substance we need to understand? The food substance we are talking about is glucose, the main product of respiration. Which food substances or nutrients we are talking about from respiration? Hheee?

L8: Glucose or carbohydrate, fat or protein.

T2: Yes, glucose, carbohydrate, fats and proteins but now we will talk about carbohydrate. So respiration is the release of food substances. So before we continue, I want you to take note: energy can only be released from food substance or can only be converted from one form to another form, but energy can never be produced. So stay away from that word. Do not say respiration is a production of energy from food substances. Energy can never be produced, created but only converted from one form to another. As energy from the sun, so you can only get energy from the sun, so all those energy that we use either that we get from food substances we only convert from one form to another. For instance, from light energy to kinetic energy, then for movement. So that's what I want you to know. These energy we are talking here, that we release from food substances during respiration we don't produce it, we don't create it, we only convert it from one form to another. So as we are eating food it depends on the food we eating. If we eat plant that energy that will be released will be in one form then you convert it into whatever form. The most important one is a definition that it's a release of energy from food substances. So that is a general definition of respiration you need to know that respiration takes place both in plants and animals, in your eye tissues, in your body, is your breast tissue. Simple because all of them have living cells and need to respire. So respiration takes place both in plants and animals.

(Long pause), so after we know that it takes place in both there are two types of respiration. So there are two types of …………so there are two forms of respiration (repeating). Even though it is a release of energy from food substances, comes into two forms.

Lrns: (all)aerobic and anaerobic respiration (talking all together).

T2: I want you to keep quiet and pay attention. So two types of respiration, aerobic and anaerobic respiration. Each two types of respiration, so you need to know definition and formula. Are you following?

Lrns: (all) yes Mrs.

T2: Two types of anaerobic respiration, if you go to page 52, in the module…

L7: excellent?

T2: in the module they are saying that it is a release of energy form food substances, excellent is on page 36. So that takes us to the equation of respiration. Teacher writes the equation on the board as learners dictate the information from page 52.

Word equation of respiration: Glucose + Oxygen $\longrightarrow$ Carbon dioxide + Water +Energy

T2: Symbol equation?

Lrns: (all) $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$ + Energy

It is a release of energy…

T2: Yes, is a release of energy but there is a word that they are using ATP, but we will come to that later. I will clarify that later. That is the equation (pointing at the equation on the board) you learn in grade 9 and 10. So we will come to the uses of energy later.

Long pause….Aerobic respiration is the release of relatively large amount of energy. What does relatively mean?

L8: Small.

T2: Aerobic respiration is the release of relatively large amount of energy from glucose in the presence of oxygen. The types of respiration whereby glucose is broken down in presence of oxygen to release energy. You need to know it. If you have a number in front of an element and a valency at the end of an element you multiply the number with the valency…

Lrns: (all) Whuu!

T2: That I will leave it there this is for physical science. Anaerobic respiration: yeast and lactic acid (in muscles). When you run example a 100m you may even corrupt, collapse.

L7: Laughing

T2: Collapse but not corrupt.

Lrns: (all) Hahaa!

T2: Mbukusa (pseudonym), what are you laughing? Which mean you never make mistakes in your life? Next time if you do that I will chase you out because you know everything.

Teacher continue explaining: if there is too much lactic acid, the muscles become tired. You can no longer run fast. The amount of energy being released is small compare to aerobic respiration. They can complain about muscles pain and collapse. You are releasing energy but it is not enough. Now we will talk about yeast. What is yeast? Anyone who can tell us what is yeast?

L9: Is a powder!

T2: Is a powder used to make cake or bread. What are the ingredients needed when you prepare bread?

Lrns: (all) Sugar, water, yeast, salt

T2: Some of them are written baking soda but original is written yeast. That powder is made up of microorganisms and need to respire. Are you following?

Lrns: (all) Yes Mrs.

T2: What do they need to respire if they need to?

L9: Sugar!

T2: When you make cake, you put the ingredients in the container and you close the container. Then you close the container where will they get oxygen since they need to respire?

Lrns: (all) No way

T2: Then they will turn into anaerobic respiration each type of organism will respire but then the type we call it anaerobic respiration. If you go to page 67, I want you to see the difference.

Glucose + Carbon dioxide → Oxygen + Alcohol

L7: Now Mrs, is it now CO_2 not oxygen?

T2: No, is CO_2. Remember we don't keep this dour for long period of time because it becomes sour because of alcohol being when you eat they form a feeling like lemon, a fun taste produced during anaerobic respiration. If you live your dough for ….it will rise because of CO_2. So that's something you need to know.

Lrns: (all) Yes, Mrs.

T2: The CO_2 is released during anaerobic respiration. Equation in symbols written down on the board. So that's chemical equation in anaerobic respiration. When they making beer they are also using yeast, when they are making bread, baking they…..

To become lighter, taste to cake/bread to have a nice taste is because anaerobic. Then in wine making yeast is used in fermentation for Tombo, Ndjabula. That's where alcohol is produced. The last thing I want to you to know is why we need energy. On page 53…they gave uses of energy in the body, number one for contraction of muscles. When you are not doing strenuous activities, you are using aerobic respiration. For instance in the liver. The body takes out necessary amino acids. The part that……………..amino acid...

Carbon hydrate (protein synthesis), for growth and repair. For instance for those who like to bath and scratch their skin they are killing some cells. If you are like me there is no way you will be lighter. For you to climb on top of that mountain you need energy. Production of heat needed for warm. Right now all of us nobody is freezing, the body have its own mechanisms to keep the body warm. The burning of our glucose to release energy keeps our bodies warm.

Now the comparison of the two types of respiration. During anaerobic respiration glucose is partially broken down to release relatively small amount of energy. In aerobic respiration, glucose is completely broken down to release relatively large amount of energy. Any question?

L10: Where does the rest of glucose go?

T2: In the body next we will talk about effects of exercise on respiration. I want you to know the differences between the two types of respiration. Aerobic respiration is the release of energy in presence of oxygen and anaerobic respiration is the release of energy in the absence of oxygen. They are two types of anaerobic respiration in words and symbols for yeast and in muscles.

$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2 + 118\ KJ$

Glucose ⟶ Alcohol+ Carbon dioxide + Energy

Glucose ⟶ Lactic acid + Carbon dioxide

L11: Mrs, sometimes you are making bread and put yeast but it did not rise. What happen?
T2: You did not put enough yeast. Otherwise you can use self-rising flour.
L11: Sometimes, it is just hard, it is not rising.
T2: Because anaerobic respiration did not take place because it …..reads on page 69 in the module also, because CO2 makes the dough to rise and cake taste, make dough lighter.
L12: During anaerobic respiration.
T2: No!
L13: Is alcohol needed in our bodies?
T2: Alcohol is needed but not as much.
L7: Mrs, can you make dough to rise if you just add alcohol?
T2: No, alcohol is not alcohol that makes dough to rise but carbon dioxide. Carbon dioxide is what makes dough to rise.
L6: Stupid question! Flour already self-rise, what if you add yeast?
T2: No, not all of them are self-rising!
L7: Can that be in examinations? Like that equation for respiration?
T2: Yes, you need to know it.
L13: This muscles, do not have a chemical formula?
T2: No, this do not have a chemical formula.
L13: Mrs, what will you advise to a runner?

T2: You just need to breathe as fat to make sure the body has enough oxygen to replace the lost. If you are fit blood is flowing well and oxygen lost will be replaced.
L14: What is ferment?
T2: Is a sour taste, the breakdown of glucose e.g in *oshikundu, omaheu*….
L13: Is *Oshikundu* not alcohol? *Omaere* also? Which mean we are eating rotten food?
T2: Not rotten so to say.
L13: It means every time we are eating bacteria.
T2: Not all bacteria, microorganisms are harmful.
L14: Also that thing people are making in Khorixas?
T2: It can last for how many days? For three days. The *maheu* also.
L8: Mrs, when you are running, is it lactic acid make you pain? Not tiredness?
T2: Yes, not tiredness, is lactic acid due to lack of sufficient oxygen in the body
L8: Not tiredness?
T2: Not tiredness.
L14: Is it true things?
T2: Yes, is true thing. If I say you run 200m tomorrow you may faint or collapse because of lack of oxygen, until some glucose is broken down to release energy.
L15: Mrs, will you bring on chemical equation of respiration in examinations?
T2: You need to know which elements are in glucose and CO_2 and balance it.
L15: You need to memorize it.
T2: Not really, but you need to know. When you memorize only you will forget.

Appendix 6A: Model Practical Activity lesson 1

Biology: Respiration **Date: 22 July 2014**

Grade 11

Group work practical activity

Materials needed:

1. Plain self-rising flour/ Plain flour and 2 teaspoons of dried yeast with 1 teaspoon of sugar
2. 1 tablespoon of salt
3. butter for greasing and lubricate the tin/pot
4. Luke warm water 400ml

Repeat using the same procedures but using warm water and cold water also to see the effect of temperature on enzyme activities.

Procedures:

Step 1: Mix dried yeast and sugar with a few drops of water first. Then add enough water estimating the amount of flour you are using.

Step 2: Sift the flour and salt into a bowl. Make a well in the centre and add the water and yeast (if you are not using self rising flour). Mix well until the dough comes away from the sides of the bowl. If the dough comes away it is well done, so you can leave it for 5 minutes.

Step 3: Knead the dough with your hands or a well made wooden rod for 10 minutes in order to make it ready to use.

Step 4: Put the dough into the bowl and cover and leave it for an hour in a warm place until it has double size (rised).

Step 5: Knead/ press and stretch the dough again for a few minutes and place the dough into a greased loaf tin or shape into balls and place into a baking tray and observe what happen again and record your findings. Bake the dough for 25-30 minutes in an oven at 230 ºC

NB: Take note of what happen to the dough when different temperatures are used during the experiements and be able to reason.

Activity questions:

1.Why the ready dough has be placed into a greased loaf tin or baking tray? (2)

2. What did you notice when cold water or warm water was used for the experiment? (2)

3. Give reasons to the observations you have recorded during these experiments. (2)
4. What can you conclude about this experiment based on your observations? (2)

Adapted fromTESSA reports (2012, p.8).

Biology: Respiration

Practical lesson 2 (group work)

The purpose of the following experiment is to see whether carbon dioxide is produced by yeast during fermentation.

Materials needed:

1.Test tubes (2)

2. Yeast

3. Sugar

4. Liquid paraffin

5. Limewater or hydrogencarbonate indicator solution

6. Two plastic or rubber corks with holes to prevent air to enter

7. A thin glass tube/plastic tube that leads from tube A to tube B (the end of this tube is below the surface of the liquid in the tube B and this is to make sure that any gas produced in tube A is bubbled through the liquid in tube B.

Activity questions:

1.Why was boiled water is used for making up the sugar solution?

2.Why was the solution in tube A covered with liquid paraffin?

3.What change would you expect to see in tube B?

4. What gas has caused this change?

5. Where has this gas come from?

Adapted from the Biology module by Ngepathimo (2008, Pp 68-69).

Biology: Respiration

Grade 11

Case study1 and activity 1

One of Mrs Sharp's former learner, Mpho, had started working in a local bakery. Mr. Sharp asked Mpho to come and talk to his learners about work in the laboratory. Mpho enjoy his job and was pleased to do that.

He explained that the main ingredients of bread are: flour, yeast and water. He had brought some fresh yeast and some dried yeast to show the learners. He put some of the yeast in a small bowl, added some warm water and a small spoonful of sugar. He asked the learners to keep an eye on the mixtures as he was busy mixing in order to see if they noticed any changes. In the meantime, he explained how to make bread.

Mpho told the class that yeast is a single-celled organism. Like all living organisms, yeast gets its energy during respiration. He asked the learners what they knew about respiration and was impressed with their responses. Yeast can respire without the need for oxygen (anaerobic respiration). As it respires yeast produces carbon dioxide gas and alcohol.
By now the learners had noticed that the bowl of yeast, water and sugar had started to froth up with lots of tiny bubbles. Mpho had brought some samples of the bread he made which he passed round for the learners to examine. He asked the learners why the bread did not taste of alcohol. Before he left, Mpho explained what qualifications he had and described the training he had received. One day he hopes to own his own barkery and intends to speicialize in making different kinds of bread from other countries.

NB: Using the information in this case study, student can able to answer the following questions and they can also practice on how to make bread at home. Teachers can also arrange a visit to a local bakery for learners to see how things are done and be able to ask their own questions.

Activity 3: questions about yeast

1.Where do you find yeast naturally?

2.How is yeast produced commercially now?

3.What special conditions are required for yeast growth and multiplication?

4. How big is a yeast cell?
5. What is the most important difference in the growth conditions for the production of yeast cells and the use of yeast cells in baking?
6. What is the meaning of the scientific name of bakers yeast?

Adapted from TESSA reports (2012, Pp.10-11) and accessible at http//: www.tessafrica.net

Appendix 7: Observation Schedule

OBSERVATION SCHEDULE

Expected classroom activities	COMMENTS
1. Use of prior knowledge a) Introduction b) Throughout c) Conclusion	
2. Use of language a) Instructions b) Code switching c) Nature of questions asked d) Teacher-learner interactions	
3. Teaching strategies a) Lecturing b) Questions and answer c) Group discussion d) Use of Technology e) Activities -practical -investigation f) Scaffolding a) Answering of questions (Teachers & learners) b) Relating to EK. c) Explanations d)Examples	

e) Redirecting of questions	
4. Learner-Support materials a) Worksheet b) Notes	
5. Consolidation of Concepts	
6. General lesson progressive a) Flow of lesson	
7. Gender sensitivity	