

https://dspace.org/

Exploring Grade 10 rural physical science teachers' perceptions and usage of everyday words in Acornhoek science classrooms, Mpumalanga Province

Zulu, Sphamandla Innocent

2018

https://hdl.handle.net/10539/26487

Zulu, Sphamandla Innocent. (2018). Exploring Grade 10 rural physical science teachers' perceptions and usage of everyday words in Acornhoek science classrooms, Mpumalanga Province, University of the Witwatersrand, https://hdl.handle.net/10539/26487

Downloaded from a DSpace repository. https://dspace.org/

Exploring Grade 10 rural physical science teachers' perceptions and usage of everyday words in Acornhoek science classrooms, Mpumalanga Province

Sphamandla Innocent Zulu

Student number: 700650

Protocol number: 2017ECE027M

Supervisors: Prof. Samuel Oyoo

Dr. Thabisile Nkambule

A dissertation submitted to the Faculty of Humanities, University of the Witwatersrand in fulfilment of the requirement for the degree of Master of Education by Research Report

Johannesburg, South Africa
March 2018

ABSTRACT

Science is a specialized language on its own and literature has revealed that science learners face conceptual challenges when learning about science concepts and words which are used in both everyday and science classroom with different meanings according to context of use. Science as a language is composed of scientific concepts (technical words) and ordinary words (non-technical words), of which the latter is the focus of this study because of its importance in ensuring sound comprehension of the technical words for effective teaching and learning of science. As such, teachers also need to mediate the non-technical words, especially Everyday Words when used in Science (EWS) classroom context, because they serve as conveyor belts of meanings inside the classroom and if explicitly mediated it can help enhance the teaching and learning of science.

The purpose of this study was to explore Grade 10 rural physical science teachers' perceptions and usage of everyday words in science context during teaching. The study also sought to understand teachers' level of awareness with EWS difficulties in learning science, while it also critically analysed factors shaping physical science teachers' perceptions and usage of EWS. To unearth rural teachers' language practices, this study used a case study design and qualitative research approach drawing from Vygotsky's concept of mediation, Scott, Mortimer and Ametler's concept of pedagogical link-making; and Mortimer and Scott's concept of social language of science as conceptual framework. Research data was collected through ten classroom observations of Grade 10 physical science lessons and individual interviews with the participant teachers from rural settings of Acornhoek, Mpumalanga Province.

The main findings of this study illustrates that greater percentage of classroom talk was teacher talk. In their talk, teachers were explicit in explaining the technical words while either ignoring or implicitly addressing the non-technical words, especially EWS. Additionally, teachers' perceptions of the value of addressing non-technical words in their teaching varied. The study also established that the teachers' language practices were to some extent influenced by the rural contextual social realities, teacher content knowledge, teacher knowledge of EWS and the importance of science language, and other several personal and contextual constraints. The findings also shown that rural Acornhoek physical science teachers were not aware of the learners' difficulties instigated by the use of EWS, and more disturbingly is that some teachers also lack knowledge of the contextual meanings of EWS.

The paucity of physical science education research in rural schools has not been able to offer account of teachers' perceptions and usage of EWS during teaching in rural schools. Hence, this study as

introductory for other science education researchers in researching teaching and learning physical science in rural schools, more specifically the understanding of STL, influence LOLT and the LOLTS. The findings of this study demonstrates that teachers are often oblivious of the functional value of EWS due to their negative perceptions hence their lack of explicit explanation of EWS when encountered during teaching and such practice is influenced by various factors. Therefore, this study recommends research intervention intending to equip teachers with skills in noting and dealing with language demands in their classrooms.

Keywords: *Science Teachers" Language (STL), Technical words, Non-technical words, Language of Learning and Teaching (LOLT), Everyday Words used in Science context (EWS), rural, teaching physical science, and perceptions.*

DECLARATION

I **SPHAMANDLA ZULU (700650)** declare that this research study is my own work. It has not been submitted before for any other degree or examination in any other university. All the work taken directly from other works has been cited accordingly and the full list of references has provided. I fully understand that the University of the Witwatersrand will take disciplinary action against me if evidence suggests that this is not my own unaided work or that I failed to acknowledge the sources of the ideas or words in my writing.

……

University of the Witwatersrand, March 2018

Protocol number: 2017ECE027M

ABBREVIATIONS

ACE - Advanced Certificate in Education

CAPS - Curriculum and Assessment Policy Statement

DBE – Department of Basic Education (Republic of South Africa)

DoE – Department of Education (Republic of South Africa)

EFAL - English First Additional Language

EWS - Everyday Words used in Science context

FET - Further Education and Training

KZN - KwaZulu-Natal

LCA - Learner-Centered Approach

LOLT - Language of Learning and Teaching

LOLTS - Science contextual Language of Teaching and Learning physical science

MSTA - Mathematics, Science and Technology Academy

NOS - Nature of Science

NS - Natural Sciences

NSC - National Senior Certificate examination

NSNP - National School Nutrition Programme

PG - Postgraduate

PGCE - PostGraduate Certificate in Education

PLM - Pedagogical Link-Making

QATA - Question and Answer Teaching Approach

QCA - Qualitative Content Analysis

SADC - Southern African Development Community

SCOP - Science Community of Practice

SCT – Sociocultural Theory

SMC - Subject-Matter Centered

SMT - School Management Team

SSIP - Senior School Intervention Programme

SSMK - Science Subject Matter Knowledge

STL - Science Teachers' Language

TCA - Teacher-Centered Approach

TIMSS – Trends in International Mathematics and Science Study

ZPD – Zone of Proximal Development

ACKNOWLEDGEMENTS

I would like to express my genuine gratitude to my supervisors: Dr. Thabisile Carol Nkambule and Prof. Samuel Ouma Oyoo for their professional guidance, patience, support, encouragement and profound advices. You have been the greatest supervisors who always saw something good in me, even at difficult times. This study would not been possible without you. Thank you!!

To my family, thank you for your prayers, love, words of wisdom and encouragement, endless support towards this research and your permission for me to do this study rather than working, I know it was hard but thank you. You are a great family and thank you for your patience, support and endless love even though I would complain to you about my academic pressure but you always comforted me and also reminded me of the bigger picture of the study. Much appreciated!

Through this study I met a family away from home, the research colleagues and I would like to thank you all for your inputs in this study; Nonhlanhla Kunene, Xolile Mazibuko, Khairoon Nisha, Lebogang Molefe, Dr. Dan Na Allah, Addmore Hapanyengwi, and most importantly Annie Mafunganyika and Hlamulo Wiseman Mbhiza. Dr Mbhiza and Dr Mafunganyika thank you so much for teaching me research, for all the time you spent helping me to develop academic language and skills, thank you 'buddy'. To Dr. Nkambule, your critical but thoughtful comments were very helpful in this study. You were not only a supervisor to me but a mother, a sister, a friend, a counsellor, and an advisor. Thank you so much!

The financial assistance of the National Research Foundation (NRF) through my supervisor Dr Nkambule, your support towards this research is highly acknowledged. However, opinions expressed and conclusions arrived at, are those of the author and are not necessarily to be attributed to the NRF.

I also like to thank the physical science teachers from Acornheok schools, Mpumalanga Province for allowing me to intrude their teaching spaces and for their time in sharing their views on science teaching. It was nice working with you all, thank you.

I can do all things not by my power but through Christ, I sometimes felt like giving up but I thank God who continuously gives me wisdom, strength and guidance.

DEDICATION

I dedicate this dissertation to my mother Sizakele Mathenjwa and to my late father. Special dedication to my mother, thank you mom for all your support and by being the pillar of my strength. To the most high God, thank you Lord this dissertation was not possible without you. May the glory be unto you Lord!

TABLE OF CONTENTS

ABSTRACT i
DECLARATION iii
ABBREVIATIONS iv
ACKNOWLEDGEMENTS vi
DEDICATION vii
TABLE OF CONTENTS viii
LIST OF TABLES xiii
LIST OF FIGURES xiv
LIST OF PHOTOGRAPHS xv
LIST OF APPENDICES xvi

CHAPTER 1: UNDERSTANDING THE COMPLEXITIES OF SCIENCE TEACHERS' LANGUAGE AND RURAL SCIENCE EDUCATION 1

1.1 The importance of science education and science teachers' language 1

1.2 Rural science education and research 3

1.3 Background of the study 4

1.3.1 The state of physical science in South African schools 6

1.3.2 Physical science curriculum issues 8

1.3.3 Issues with language of teaching 8

1.4 Problem statement 9

1.5 Rationale of the study 11

1.6 Purpose of the study 12

1.7 Objectives of the study 13

1.8 Main research question 13

1.8.1 Sub-research questions 13

1.9 Significance of the study 14

1.10 Operationalization of terms 14

1.11 Structure of the dissertation 16

CHAPTER 2: THE NATURE OF SCIENCE TEACHERS' LANGUAGE: A REVIEWED LITERATURE 18

2.1 Introduction 18

2.2 Issues with LOLT and science teaching 18

2.3 Understanding the role of language in physical science education 21

2.4 The teaching and learning of physical science 23

2.4.1 Technical component of science teachers' language 25

2.4.2 Non-technical component of science teachers' language 27

2.5 Prevalent difficulties with science teachers' language including EWS 28

2.6 Teachers' awareness of learner difficulties with everyday words used in science context 30

2.7 Teacher's mediational approaches to develop word knowledge 31

2.8 Teachers' perceptions of EWS in relation to physical science teaching 33

2.9 Understanding rural education and rural education research in South Africa 34

2.9.1 The teaching and learning of physical science in South African rural areas 36

2.10 Chapter summary 37

CHAPTER 3: CONCEPTUAL FRAMEWORK 39

3.1 Introduction 39

3.2 Mediation 40

3.3 Social language of science 44

3.4 Pedagogical Link-Making: To support knowledge building 47

3.4.1 Approach 1: Making links between every day way of explaining and scientific ways of explaining 48

3.4.2 Approach 2: Analogical link-making 49

3.4.3 Communicative Approaches 49

3.5 Chapter summary 50

CHAPTER 4: RESEARCH METHODOLOGY 52

4.1 Introduction 52

4.2 Research paradigm 52

4.3 Case study research design 53

4.4 Research approach 55

4.5 Research data collection methods 55

4.5.1 Classroom Observation 56

4.5.1.1 Process of observation: Observation Schedule 58

4.5.2 Interviews 59

4.5.2.1 Interview schedule 61

4.6 Context of the study 61

4.7 Research sampling 62

4.7.1 Research participants 63

4.7.1.1 Participating Schools 64

4.7.1.2 Participating Teachers 71

4.8 Actual data collection 74

4.8.1 Gaining access to research sites and consent of participants 74

4.9 Data organization and process of analysis 75

4.10 Data analysis 82

4.10.1 Analysis in terms of link-making and the communicative approach 83

4.10.2 Qualitative Content Analysis 84

4.11 Chapter summary 86

CHAPTER 5: TEACHERS' PERCEPTIONS AND USAGE OF EVERYDAY WORDS IN PHYSICAL SCIENCE TEACHING: PRESENTATION OF FINDINGS AND DISCUSSION..... 87

5.1 Introduction..... 87

5.2 Teachers' mediational approaches to and awareness of everyday words used in physical science teaching..... 89

5.2.1 Teaching approach to everyday words use in physical science lessons 89

5.2.*2 Teaching approaches to physical science including EWS* 93

5.2.2.1 *Teachers' explanation or lack thereof of everyday words used in science context* 104

5.2.3. Teachers' awareness or lack thereof of the difficulty posed by everyday words used in science context..... 111

5.3 The key to understanding a subject is to understand its language: Nature of EWS usage..... 114

5.3.1 Ayanda's use of everyday words in science 115

5.3.1.1. Ayanda's usage of the word 'Structure'..... 118

5.3.1.2. Ayanda's usage of the word 'Stable' 119

5.3.2. Thandi's use of everyday words in science..... 120

5.3.2.1. Thandi's usage of the word 'Reaction' 122

5.3.2.2. Thandi's usage of the word 'Phases' 123

5.3.3 Thabo's use of everyday words in science 124

5.3.3.1 Thabo's usage of the word 'Constant' 125

5.3.3.2 Thabo's usage of the word 'Media' 126

5.3.4 Simphiwe's use of everyday words in science..... 127

5.3.4.1. Simphiwe's usage of the word 'Prepare' 129

5.3.4.2 Simphiwe's usage of the word 'Solution' 130

5.4 Tension between general proficiency in "plain English" and science contextual proficiency in LOLTS..... 131

5.4.1. I code-switch, do you? The role of code switching in the mediation of SSMK including EWS 131

5.4.1.1. Thandi: 132

5.4.1.2. Ayanda: 133

5.4.1.3. Thabo: 134

***5.4.1.4**. Simphiwe:* 135

5.5 "Nobody has to teach something invaluable" 137

5.6 Chapter summary 142

CHAPTER 6: RE-IMAGINING EWS IN PHYSICAL SCIENCE TEACHING: ANALYSIS OF FINDINGS AND CONCLUSION 144

6.1 Introduction 144

6.2. Physical science teachers' perceptions and the usage of everyday words in science classroom context 145

6.2.1. Teachers' approaches in using EWS during physical science teaching 145

6.2.2. Explanation of EWS during physical science teaching 146

6.2.3. Teachers' perceptions of EWS 147

6.3. Teachers' awareness of the difficulties instigated by the use of everyday words in science context in learners' learning of science 148

6.4. Factors that shape rural physical science teachers' perceptions and the usage of everyday words and their awareness/unawareness of difficulties with EWS 149

6.5. Re-imagining the role of EWS: Summary of findings 150

6.6. Implications of the findings 153

6.7. Recommendations for future research 153

6.8. Limitations 153

6.9. Reflections 154

REFERENCES 157

LIST OF TABLES

Table 1.1 Summary of Grade 12 learners' performance in Physical Science from 2013-2017...…...…6

Table 3.1 Four categories of communicative approaches used in classrooms…….…....50

Table 4.1 Summary of the observed lessons ……..……..……...58

Table 4.2 Interview information with each participant…….…….…...61

Table 4.3 Tick Table for participating schools……..…..….65

Table 4.4 Summary of selected physical science teachers……..……..…..…73

Table 4.5 Categorization of data……...……79

Table 5.2.2 Summary of Teachers Pedagogic Approaches……..……..104

Table 5.3.1.1.Summary of everyday words used in science teaching during Ayanda's lessons……....116

Table 5.3.1.2 Contextual use of some everyday words in science teaching during Ayanda's lessons....117

Table 5.3.2.1. Summary of everyday words used in science teaching during Thandi's lessons……..120

Table 5.3.2.2. Contextual use of some everyday words in science teaching during Thandi's lessons….121

Table 5.3.3.1. Summary of everyday words used in science teaching during Thabo's lessons…….....124

Table 5.3.3.2. Contextual use of some everyday words in science teaching during Thabo's lessons…..125

Table 5.3.4.1. Summary of everyday words used in science teaching during Simphiwe's lessons…….127

Table 5.3.4.2. Contextual use of some everyday words in science teaching during Simphiwe's lessons..128

LIST OF FIGURES

Figure 2.1 Summary of teacher practices on LOLT and its implications for comprehension of SSMK……...……21

Figure 2.2 Classification of science teachers' language……..25

Figure 2.3 Conceptual knowledge developing alongside an increased level of word knowledge..…32

Figure 3.1 Triangular relationships between words, language and knowledge…….……..…46

Figure 3.2 Integrating and differentiating between everyday and scientific views……....48

Figure 4.1 Process of interview data analysis through QCA……85

Figure 6.1 Teachers networked factors influencing the teaching of physical science content….....152

LIST OF PHOTOGRAPHS

Photograph 4.1: Zabalaza Secondary School……..……..…67

Photograph 4.2: Some educational support for Zabalaza Secondary School……68

Photograph 4.3: Sunshine Secondary School……..…….…..…..69

Photograph 4.4: Ithemba Secondary School…….…….…..….70

Photograph 4.5: Siyathuthuka Secondary School…….…….……...71

Photograph 4.6: Horizontalization of interview and observation data……..……...77

Photograph 4.7: Process for the development of categories……...…..78

LIST OF APPENDICES

APPENDIX 1: Classroom Observation Schedule……..175

APPENDIX 2: Interview Schedule……176

APPENDIX 3: Sample of Interview Transcript for Ayanda……...……..178

APPENDIX 4: Sample of Classroom Observation Transcript for Ayanda……..…...……187

APPENDIX 5: Approval Letter from Mpumalanga Department of Education..…….....199

APPENDIX 6: Information Letter for Principals……..…...…….201

APPENDIX 7: Information Letter for Teachers and Consent Forms……...…..…...203

APPENDIX 8: Information Letter for Parents and Consent Forms……...……...206

APPENDIX 9: Information Letter for Learners and Assent Forms……..……..…209

APPENDIX 10: Ethics Clearance Letter……..……..……..212

APPENDIX 11: Samples of coded teacher interviews……..……..…...……..…213

APPENDIX 12: Samples of coded teacher observations……..……..…...……..…217

APPENDIX 13: Sample of a theme development process……..…...……..…219

CHAPTER 1

UNDERSTANDING THE COMPLEXITIES OF SCIENCE TEACHERS' LANGUAGE AND RURAL SCIENCE EDUCATION

1.1 The importance of science education and science teachers' language

Various authors contend that education is a social process that is inextricably linked to the discourses of social justice[1] and transformation (Ward, 2007; Ndlovu, 2011; Hytten & Bettez, 2011; Mthethwa-Sommers, 2014). Within the broad perspective of education, science and mathematics are traditionally seen as some of the key areas of knowledge for the development of individuals and the advancements of societies in general, as well as addressing issues of social justice, equity and transformation (Reeve & Sharkawy, 2014; Leonard, Chamberlin, Johnson, & Verma, 2016). Reeve and Sharkawy (2014) posit that science education for social justice focus on "making science education more accessible to all students, especially those belonging to groups that are traditionally marginalized from science education" (p. 283), such as Black dominated rural spaces in particular. Along the same line of discussion, considering that the current South African education system bares major scars of the apartheid assumptions that systematically excluded Blacks, Indians and Coloureds from participating in subjects such as science and mathematics. In a democratic dispensation, there is a need to understand the nature of physical science teaching in the current South African rural science classrooms by teachers who were dominantly trained in teachers' colleges. This study assumes that rural teachers and learners were most affected by the segregation and racialization of science and mathematics during apartheid regime, as compared to urban-based teachers and learners that had and continue to have better equipped science laboratories and textbooks (Balfour, Mitchell & Moletsane, 2008).

[1] Social justice through education means paying attention on redressing inequities of the past by recognizing that all learners are equally entitled to good teachers, conducive teaching and learning spaces, irrespective of their socio-economic background, geographic location, race, gender or creed (Ndlovu, 2011). As such, a socially just science education should encompass equal access to the curriculum, resources, good science teachers, and favourable conditions for learning to develop and improve all learners, and it needs to be sensitive to the varying needs and circumstances of all (Ndlovu, 2011).

The importance of science education puts science teachers, as knowledgeable others, at the core of scaffolding and transforming[2] scientific knowledge, to ensure that learners understand science contents. Teachers are required to do this through practical work and appropriate usage of science language, because language learning involves learners appropriating science language as a meditational tool and as an object (Mansour, 2009). Teachers are the focus of this study, as they are expected to explicitly mediate the meanings of science concepts through the use of science language among other cultural tool. Language is used in science classrooms to convey a particular meaning of science concepts; it is also key to the internalisation of complex science ideas. Oyoo (2017) argues that the role played by language in science education remains misunderstood and under-researched in South Africa, including rural schools for the study. Even when issues of learners' low outcomes in science and mathematics are addressed, various strategies have and continue to disregard the role of science teachers' language during teaching and learning (Mji & Magkato, 2006; Kriek & Grayson, 2009). This is due to difficulties with science content being ascribed to general proficiency in English, the Language of Learning and Teaching (LOLT) (Dlodlo, 1999; Rollnick, 2000; 2010; Ferreira, 2011), while little or no reference being made to the Nature of Science[3] (NOS), or science being a language (Childs, 2006).

Considering the above brief background, it is significant to explore science teachers' use of language, in particular the usage of non-technical words during physical science teaching in rural science classrooms, given that rural context is marginalised by science education researchers. It is important at this stage to explain that science teacher's language used during instruction is divided into two categories: Technical and Non-technical components (Oyoo, 2011). Technical component include scientific concepts and everyday words used "as" science words implying new scientific meanings, while the Non-technical component include everyday words used "in" science context (Oyoo, 2017). To show the significance of explaining everyday words used in science, when the National Senior Certificate (NSC) diagnostic report were responding to Grade

[2] Shulman (1986) posits that during the processes of meaning-making, teachers need to configure strategies to make the contents of the subject matters to be more accessible to the learners.

[3] NOS is the epistemological underpinnings of the activities and products of science (Lederman, Antink & Bartos, 2012). This necessitates the scientific language which is precise, unique and contextualized with respect to science education (Bulman, 1985; McComas, 2014).

12 physical science learner's errors and misconceptions, the report suggests that "Teachers should stick to and emphasize the definitions in the *Examination Guidelines*" (DBE, 2018, p. 180) for words such as 'at rest', 'constant' velocity, 'net' force among others. If learners encounter difficulties with contextual definitions of everyday words when used in science classroom context (EWS) at Grade 12 level, it could be worse in Grade 10, hence lack of research in this grade to understand the nature of teacher's use of every day words within non-technical words while teaching. Understanding the role of EWS addresses the need for science teachers to lay proper foundation of EWS at Grade 10 level, so that learners are encultured into the science discourse and are able to talk science (Lemke, 1990). So exploring the Grade 10 physical science teachers' understanding and use of EWS is vital because non-technical words serve as the bridge for learners' understanding of technical words[4], which necessitates teachers' explicit explanation of the EWS during science lessons.

1.2 Rural science education and research

There are different factors at play that shape processes of teaching and learning within science classrooms, particularly within rural and farm schools, which involve the nature of the schools and their geographic locations (Muwanga-Zake, 1998; Gardiner, 2008). Authors state that teachers and learners in rural and farm schools continue to encounter specific contextual challenges such as absence of science laboratories, lack of functional school or public libraries, shortage of qualified science teachers, teacher's challenges with proficiency in general English, and specifically proficiency in physical science teachers' language which shapes the effectiveness of teaching and learning within science classrooms (Moletsane, 2012; Masinire, 2015). Considering the aforementioned factors, it is important to popularise rural education research in order to configure strategies to enhance the quality and standard of education in this research area. In addition, the education system needs to also focus on the challenges of rural science teachers that are unique to the rural context, in particular their place-based perceptions and teaching experiences of physical science which could positively or negatively influence

[4] Technical words are words or terminologies specific to a science subject, for example, 'chromosome' in biology, 'capacitance' in physics, or 'anion' in chemistry (Oyoo, 2009), these words define and give identity to science subject. While non-technical words are the words that define or give identity to the particular language of learning and teaching used in a classroom or the language of a science text, these are everyday English words that assume specialized/contextualized meaning in the science context (see Oyoo & Semeon, 2015; Oyoo, 2017).

learners' performances in the subject. Childs (2006) suggests that, "to study science is to learn a foreign language and unless one masters the language one cannot properly understand the science" (p. 17), suggesting the importance of understanding rural teachers' EWS, the language usage and the choices of non-technical words during lessons. Teachers are expected to transform science content and also teach language skills appropriate for physical science, to introduce and mentor learners to the science community and this study seeks to unearth the development of language skills by rural physical science teachers' during the teaching of science content.

The debates on physical science education in rural schools remains unmapped in literature, due to little interest to rurality by science education researchers in South Africa (Nkambule, Balfour, Pillay & Moletsane, 2011; Moletsane, 2012). The current study addresses this research gap by engaging with Grade 10 physical science teachers within their context, to understand their usage of EWS within the non-technical component of science teachers' language while teaching science. The paucity of science education research in rural areas of South Africa, particularly in physical science education questions the extent to which issues of social justice have been addressed in rural communities and rural education 24 years of democracy (Venkat, Adler, Rollnick, Setati & Vhurumuku, 2009; Nkambule et al., 2011). It is because of the complexity and uniqueness[5] of teaching and learning science in the rural contexts that the focus on science teachers' language use in the current study is significant, to de-silence and gain insight of their unexploited knowledge.

1.3 Background of the study

The teaching and learning of science in South African schools is not a neutral act but is politically motivated since science and mathematics are viewed as some of the key subjects in redressing the past inequalities of apartheid (Msila, 2007; Gardiner, 2008; Spaull, 2013). This is in consideration that the apartheid education system sought to disempower Blacks and females, especially Black Africans[6] by aiming to make them inferior to learning science and mathematics for this study (Msila, 2007). To redress the past inequalities, the post-apartheid government

[5] Complexities and uniqueness of rural spaces discussed in section 2.9.

[6] Coloureds and Indians were classified as 'Blacks', and Black African were called natives during apartheid (Carrim & Soudien, 1999), but I am using Black African to refer to Black people only, excluding the Couloureds and Indians.

focused on empowering learners, regardless of their racial and gender background to confidently take science and mathematics in schools (Carrim & Soudien, 1999; Msila, 2007). While this is commended, it remains unclear how the post-apartheid government pays attention to issues of geographic locations of the schools, the nature of the schools, their resourcefulness or lack thereof, as well as the quality of teachers in general and specifically science teachers, when they plan the curriculum for all schools around the country (Gardiner, 2008; Maringe, Masinire & Nkambule, 2014; Nkambule & Mukeredzi, 2017). If the claim that teachers who teach in rural and farm schools were predominately trained during apartheid is true (Carrim & Soudien, 1999; Muwanga-Zake, 1998), it is assumed that some of them were undertrained or never trained to teach subjects like physical science.

Additionally, there are some factors that influence science teaching and learning processes within rural schools, which make the circumstances within the schools incompatible with other contexts such as urban schools' context (Muwanga-Zake, 1998; Legari, 2004). It could be argued from the reviewed literature that most schools located in rural and farm areas lack well-resourced science laboratories, and this plays a major role in the manner in which teachers teach physical science contents within these schools, and in turn influencing learners conceptual understanding and academic performance in physical science (Hlalele, 2012; Masinire, 2015; Nkambule, 2017). Considering the challenges of resources that facilitate learners' scientific rigor within rural schools, the source of knowledge for science education becomes teachers who should be well qualified (Legari, 2004) and be proficient in the contextual language used during science teaching (Roth, 2014). Importantly, however, is that science teachers should use science contextualized language during teaching and for purposes of examinations, which has to be appropriately contextualized to science context.

Moreover, Matthews (1998) states that "teachers convey the ideas of science by trying their best to explain the concepts and operations clearly, *and they make use of various strategies to enhance learners' learning* such as metaphors, demonstrations and practical work to flesh out abstractions" (p. 9) (*Italics my emphasis*). This suggests that when teaching science concepts, teachers use science specific language and EWS within non-technical words, a reason it is important to examine whether they are aware when they use them during science lessons. Thus, teachers' language use and talk within physical science classrooms, including rural classrooms

play a significant role in aiding learners' understanding of the subject matter contents (Muwanga-Zake, 1998; Legari, 2004; Oyoo, 2012). Moreover, Vygotsky (1978) posits that there is a relationship between language and thought which means science concepts cannot be understood fully unless they are represented in words that make up STL. As such, in science classrooms, science teachers cannot only confine science language issues to general proficiency in the language of learning and teaching but also to contextual proficiency in the language of science whether written or spoken.

1.3.1 The state of physical science in South African schools

The international benchmark assessments, according to Kriek and Grayson (2009), indicate that South African learners are performing poorly in science due to various teaching and learning factors. In the 2011 Trends in International Mathematics and Science Study (TIMSS), South Africa was ranked the last country (out of 40 countries) in terms of science and mathematics understanding (TIMSS, 2011; Oyoo & Semeon, 2015). The ranking and current Grade 12 learners' poor performance in physical science (DBE, 2018) brings to question the quality of physical science teaching, the role of the teacher and the nature of teachers teaching strategies employed during science teaching in South Africa. Table 1.1 summarizes the observed trends in Grade 12[7] science performance for the past five years.

Table 1.1 Summary of Grade 12 learners' performance in Physical Science from 2013-2017 (DBE, 2018)

YEAR	Physical science pass rate (30% and above)	Physical science pass rate (40% and above)
2013	67.4%	42.7%
2014	61.5%	36.9%
2015	58.6%	36.1%
2016	62.0%	39.5%
2017	65.1%	42.2%

Although the results are for Grade 12 they address the ongoing national crisis performance, which is not compatible with the rural school learners' performance due to contextual factors which influence the teaching and learning of science (Howie & van Staden, 2012; Spaull, 2013).

[7] I am using the information on Grade 12 performances because of the reviewed literature there was no published information of Grade 10 physical science performances. However, Grade 12 information could give a clear picture about the understanding of science concepts and language understood by learners from their science foundational level, which is Grade 10 in preparation for Grade 12 national examinations.

The poor performance in physical science portrays a gloomy picture for South Africa's present and future economy developments, since science is viewed as one of the vital subjects for the development of a country's economy. Science education researchers have ascribed the barrier to learning and effective understanding of science content to science language (Van Laere, Aesaert & van Braak, 2014; Oyoo, 2017). So to address the science poor performance related issues, there needs to be a comprehensive understanding of teacher's pedagogical epistemology of science, including in rural schools where practical work is foreign. Thus, the importance of this study to critically explore teachers' teaching practices, with particular attention to science language issues within science classrooms to understand how science is taught in rural classrooms, what can be learned from the teaching practices.

The poor performance and uptake of physical science has become an international issue of concern (Mji & Magkato, 2006; Kriek & Grayson, 2009; TIMSS, 2011), and in South Africa the government, business and academics are implementing policies and programmes directed at helping science and mathematics learners to improve academically. These programmes aim to develop adequate science-oriented personnel to run and sustain the nation's economy (Reddy, 2005; Oyoo & Semeon, 2015). It is for this reason the Department of Basic Education (DBE), especially in the Gauteng province, has put in place Senior School Intervention Programme (SSIP) for Grade 12 science and mathematics learners to attend on Saturdays (Oyoo & Semeon, 2015). Nonetheless, the above initiatives appear to silently neglect the state of teaching and learning physical science especially in rural schools. There seems to be a further neglect on the role of science teachers' language used in the teaching and learning of physical science in South African education research. Additionally, the South African government also implemented a national strategy for science, mathematics and technology education targeted towards improving outcomes in the Grade 12 physical science and mathematics examinations (DBE, 2012). The modalities included augmentation of teacher content knowledge, provision of capital equipment and reference material, study guides, computers and computer simulations, practice drills, as well as the provision of laboratory apparatus and consumables (DBE, 2012). However, the dynamics of science contextualised language continues to remain in the periphery of the interventions that are meant to improve science poor performance.

1.3.2 Physical science curriculum issues

The universalization of the South African curriculum across all public schools could also be a contributory factor in the poor understanding of school science knowledge, considering the contextual differences of schools that could in turn lead to different teaching approaches in response to innumerable learners' and societal needs. Rural physical science teachers, like other public school teachers, work with extensive Curriculum and Assessment Policy Statement (CAPS) (DBE, 2011) regardless of their often overlooked contextual challenges (Legari, 2004; Gardiner, 2008). Unlike other Southern African Development Community (SADC) countries like Tanzania and Zimbabwe, where physical science is taught as two separate subjects: physics and chemistry (Meana, 2009; Ncube, 2014), South Africa teaches school science as a combination of Chemistry and Physics (DBE, 2011). Even in the National Senior Certificate examination (NSC), learners write an intense paper 1 (physics) and paper 2 (chemistry) (DBE, 2018). The amalgamation of chemistry and physics could be another factor for overall poor performance and low status of physical sciences, because some learners may be stronger in one component like physics and weaker in chemistry (Ncube, 2014). To then see which component of physical science demands more attention, there could be a need to review the South African physical science curriculum and separate the two components to be two individual strands: physics and chemistry.

1.3.3 Issues with language of teaching

Considering the preceding discussion on poor performance, innumerable authors continue to argue that science learners perform poorly partly because of the use of English language (LOLT) (Dlodlo, 1999; Rollnick, 2010; Mthiyane, 2016), which is a second or third language for the majority of learners in South African schools, including in rural school. While English could be a factor in science poor performance, it is still used following debates that science is transformed and understood better in the English language. Even though, the use of mother tongue as LOLT is advocated for by the Language in Education Policy (LiEP) (Department of Education (DoE), 1997). While I acknowledge the arguments that science as a discourse has its unique language that ought to be used by teachers to share scientific ideas, and is done through the use of science contextualized language (Driver, Asoko, Leach, Mortimer & Scott, 1994; Wellington & Osborne, 2001; Roth, 2014), it is still important to note that there is a crucial role played by

general proficiency in English language because having proficiency in English language is regarded as a necessary first step to science understanding (Oyoo & Semeon, 2015). Even though, it is not yet clear at what level (measure) of English proficiency attainment would guarantee smooth teaching and learning of science. Hence, there are contentious debates about the use of learners' mother tongue languages in teaching science (DoE, 1997; Dlodlo, 1999; Rollnick, 2000; Ferreira, 2011), though the nature of science language, science being a language and having its own contextual language has been silently ignored regardless of the difficulty of EWS (Wellington, 1994; Wellington & Osborne, 2001; Oyoo, 2012). For the purpose of this study, it is important to note that the difficulty of everyday English words used in science context is irrespective of whether a teacher or a learner is a 1st or 2nd English language speaker (Cassels & Johnstone, 1985; Oyoo, 2017).

Considering the context of South African rural schools and the challenges with teaching and learning, including insufficient resources to conduct experiment (Muwanga-Zake, 1998; Legari, 2004; Gardiner, 2008), it could be argued that one of the principal ways of teaching and learning science is through teacher's talk, the spoken (verbal) and/or written wording. It is thus interesting for this study to understand how teacher's language, which is the use of EWS through classroom talk, is used to enable and/or constrain learners' access to science concepts. The language components are to be discussed in detail in chapter 2. It is therefore important for science teachers to know that when everyday English words are used in science classroom, they change to 'attain specialized meaning' or acquire science 'context meaning' (Ncube, 2014). Consequently, science teachers need to explicitly explain the contextual meanings of EWS to ensure improved comprehension of science concepts.

1.4 Problem statement

In relation to section 1.3, democratic South Africa still encounters challenges of access to efficient schooling, poor uptake and performance in physical science, especially among the previously disadvantaged communities, which include township, rural and farm areas (Msimanga, 2013; DBE, 2016). Section 1.3.1 indicates that there is poor performance in physical science subject, of concern however that proficiency in language of learning is and teaching has been viewed as the major contributor to this poor performance (Dlodlo, 1999; Rollnick, 2000; DBE, 2010; Mthiyane, 2016). The transnational studies (Cassels & Johnstone, 1985; Tao, 1994;

Oyoo, 2000: 2016) refute the assumption that proficiency in LOLT equates to greater performance in science, because science as a discourse has its own language (Lemke, 1990; Wellington & Osborne, 2001) and when English words are used in science classroom context they change from being mere English words (Marshall & Gilmour, 1990). The above discussions on physical science poor performance, draws attention to the significance of focusing on science classroom teaching generally, and specifically in rural classrooms as overlooked contexts, and understand the language of science used in learning and teaching science. This also comes after the findings that there is poor comprehension of everyday words when used in science classroom context (Tao, 1994; Oyoo, 2016). Irrespective of the documented difficulty of science learners with EWS, there is no research study that has focussed on South African science teachers understanding, perceptions and use of EWS during teaching, particularly in rural schools.

Regardless of the importance of science teachers' language and the words that compose it, it is not yet clear from the reviewed literature on how Grade 10 physical science teachers (including teachers in rural areas) pedagogically approach the use of everyday words used in physical science classrooms during teaching. Moreover, the significance of EWS and science language teaching in conceptually shaping Grade 10 science learners understating of the physical science knowledge remains unmapped in science education literature. Therefore, this study addresses an essential research gap in science pedagogy studies for teacher's use of and approaches to physical science, especially with the focus on teaching through everyday words used in the science context, which has been overlooked by most science education research studies.

Thus, this study sought to understand how EWS are used by rural science teachers during teaching. Moreover, of concern in a democratic South Africa is that previously disadvantaged communities, including rural and farm schools, experience little research in science education (Venkat et al., 2009; Nkambule et al., 2011), particularly teachers' use of science language and choices of everyday words used in science context during teaching and learning. The research gap in rural science education, especially science teachers' language usage during teaching of science, works against the need to address access and equity issues through rigorous empirical investigation of potentialities, and constraints on language use in classrooms (Venkat et al., 2009). In addition, the existence and uniqueness of rurality and rural education has been acknowledged by various authors (Moletsane, 2012; Balfour, 2012) even though there is limited

science education research conducted in this context. The paucity of research is regardless of the conception that rural schools are unique and distinct from most urban and township schools, and have different teaching and learning conditions from those observed in most urban and township counterparts (Muwanga-Zake, 1998; Gardiner, 2008).

Thus, the scarcity of research on rural schools implies that little is known of rural science teachers' language usage, in particular the understanding and the usage of everyday words in science classroom context. The dearth of place-based knowledge could be a contributory contextual factor leading to the persistent trends in science learners' poor performances which has not been scrutinized in-depth, particularly for learners' coming from poorer socio-economic backgrounds, such as rural areas (Msimanga, 2013). It is thus important for this study to understand how rural place and space influence teacher's understanding of the nature of science education, and also the language used in the classrooms during physical science teaching.

1.5 Rationale of the study

The rationale for conducting this study is vested in the well-documented rural education research findings (Nkambule et al., 2011; Moletsane, 2012; Balfour, 2012; Masinire, 2015; Nkambule, 2017), which have highlighted the marginalization of rural education and rural science education research in South Africa. It is of concern that focus of education research on rural science education is seen as insignificant considering little research, particularly rural science education, as it remains an under-researched phenomenon (Muwanga-Zake, 1998; Venkat et al., 2009). It is because of this concern the current study is located within rural schools in order to bridge the knowledge gap in the existing science education literature, due to popularised urban and township education research (Nkambule et al., 2011). Above the paucity of science education research into the teaching and learning of science in rural classrooms, physical science teachers' use of language especially the use of EWS remains unmapped in science education research. This is regardless of the view that language plays a crucial role in concept formation (Vygotsky, 1978) and this concept formation is inseperable from the symbols or words from which the language is composed (Postman & Weingartner, 1971).

When considering the South African context, the limited science education research has not offered an account of the role played by rural science teachers' language usage in physical

science classrooms, whether it enables or constrains learners' learning of physical science concepts. From the identified research gap, I conceptualized the current study to understand whether and how the rural place, space, and nature of teacher training shape physical science teachers' language usage while teaching. Furthermore, the theoretical distinction between technical words and non-technical words of science teachers' language (Oyoo & Semeon, 2015; Oyoo, 2017) is a significant research focus, to uncover teachers' understanding and teaching approaches to language use while teaching physical sciences within rural classrooms.

The existing studies that seek to gain discernment about the processes of science teaching and learning predominately focus on understanding Grade 12 teachers' and learners' learning, teaching of the subject matter contents, and minimal studies focuses on other school grades (Clerk & Rutherford, 2000; Oyoo & Semeon, 2015). I was then specifically intrigued to conduct a study with Grade 10 teachers, because the grade connects senior and Further Education and Training (FET) phases[8]. In this grade, teachers are expected to prepare learners for higher grades by laying foundational physical science knowledge for learners to build on and master, and continue to learn more new and foreign words (language) specific to physical science classrooms. While the importance of physical science content mastery cannot be overemphasized alongside teaching the subject matter contents, however the teaching of physical science is also about introducing new and foreign language specific to physical science discourse (Childs, 2006). Thus the science teachers' language becomes a bridge between the teacher, learner and science content, whereby, if not build properly it might negatively affect learners' comprehension of science contents (technical words). It is for such reasons that this study focuses on Grade 10 physical science teachers' language usage while teaching science in rural classrooms of Mpumalanga Province, South Africa.

1.6 Purpose of the study

The purpose of this study is four fold. First, it is to explore Grade 10 rural physical science teachers' perceptions of using everyday words in science classrooms. Second, is to examine teacher's usage of EWS during physical science lessons. Third, is to investigate rural physical

[8] Senior phase is where among other subjects, learners do a combination of life sciences and physical sciences as natural sciences (NS) and it starts from Grade 7 to Grade 9, while FET phase is where among other subjects, learners do physical sciences (chemistry and physics) and it starts from Grade 10 to Grade 12.

science teachers' awareness of any difficulties posed by everyday words in science classroom context. Fourth, is to critically analyse factors that might shape rural physical science teachers' perceptions and usage of specific everyday words in science context while teaching physical science lessons. This study is located within a larger research project that explores conditions of teaching and learning that facilitate and/or constrain learning in rural schools of South Africa. Even thou the larger research project explore teaching and learning conditions in general, it is open-ended while my study specifically examines physical science teaching (subject-based), precisely the understanding and the use of EWS in physical science lessons in rural schools.

1.7 Objectives of the study

Given the purpose of this study, the specific objectives of the study can be summarized as follows:

a) To gain insight into Grade 10 rural physical science teachers' perceptions of using everyday words in science classrooms.

b) To describe and interrogate teachers' EWS use during science lessons

c) To understand rural physical science teachers' awareness of any difficulties instigated by everyday words in science context.

d) To make meaning of the factors that shape teachers' perceptions and the usage of everyday words in science context.

1.8 Main research question

This study seeks to answer the following main research question:

How do Grade 10 rural physical science teachers use everyday words during physical science lessons?

1.8.1 Sub-research questions

a) What are Grade 10 rural physical science teachers' perceptions of using everyday words in science classroom?

b) To what extents are rural physical science teacher's aware of the difficulties of everyday words when used while teaching science?

c) What are the factors that shape rural physical science teachers' perceptions and usage of specific everyday words when used in science classroom context?

1.9 Significance of the study

This study will contribute knowledge on the nature of rural physical science teachers' perceptions of and usage of EWS within the non-technical component of STL while teaching science lessons, specifically the dynamics and complexities in rural classrooms. Conducting a research with rural teachers will contribute rural place-based and space-based science education knowledge, given the dearth of research in this context. In its broader intentions, this study will contribute to the existing knowledge, South African curriculum planners and teacher education institutions by adding the nature of rural physical science teachers' experiences and challenges of using everyday words while teaching physical science lessons.

1.10 Operationalization of terms

Technical words:

This study conceptualizes technical words as the scientific concepts or those words specific to a science subject/discipline (genes, atoms, cations) which gives identity to a particular science subject (Oyoo, 2009). Even though, some technical words (energy, power, force) are everyday words that are deliberately used "as" science concepts (Oyoo, 2017). However, it is important to note that this study does not focus on the technical words but the non-technical words.

Non-technical words:

Carlisle, Flemming and Gudbrandsen (2000) refer to non-technical words of science as non-topical words. Their identified non-topical words included words like 'reflection', 'predator', 'conduction'. In the same breath as Carlisle et al, (2000) this study adopted Oyoo's (2004; 2009; 2012; 2017) understanding of non- technical words being the words that defines or gives identity to the particular LOLT in use in a classroom or the language of a science context. The component of STL (non-technical words) is divided into three categories: metarepresentational terms, logical connectives, and everyday words used in science context (EWS). The study focus on EWS which consists of words that have become part of the language typical of science subjects, but have different meanings in the everyday use of a language (eg. reaction, diversity, spontaneous) (Oyoo & Semeon, 2015). EWS are the words that Carlisle et al, (2000) refer to as non-topical words.

Rural:

The operationalization of the term 'rural' was informed by the classifications of urban and rural spaces in South Africa, even though these terms may be conceptualized differently in other countries (Gardiner, 2008). Generally, rural areas are defined according to place of residence and the type of jobs residents engage in, without placing emphasis on the individuals within a particular rural space (Gardiner, 2008). This study acknowledges the complexities in defining 'rural' but as a working definition of the current study is that 'rural' is complex, dynamic and shaped by a wide range of factors including people's lived experiences within a rural space (Balfour et al., 2008; Nkambule et al., 2011). While acknowledging the fluid or tentative nature of defining rural areas, this study conceptualizes rurality as a dynamic context where lived experiences of individuals and social issues are related to the rural context (Nkambule et al., 2011). This understanding of rurality ascribes to the idea of space which sustains human existence and development outside the jurisdiction of metropolitan/city/ town authority (Masinire, Maringe & Nkambule, 2014). As such, rural spaces should be viewed according to lived experiences of individuals and as being unique to specific locations and time.

Mediation:

Mediation in this study refers to the process of using tools such as language during teaching and learning of science, and this process regulates social and mental activity (Harvey, 2011). Martin and Dean (1964) categorized mediation during teaching and learning as having implicit mediation, explicit mediation and non-mediation. Teacher's pronunciation of the meanings of EWS facilitated explicit mediation during the teaching and learning of physical science including EWS. In this stage, the teacher is conscious of the use of science contextual language including EWS, hence clearly giving an explanation of the meaning of used EWS by stating that this EWS means this or that. Implicit mediation is understood as teaching segment where teachers appeared to be unconscious of EWS explanation, where they did not verbalize that EWS means this or that but the explanation of the meaning (s) of EWS was embedded in the teacher talk. Lastly, non-mediation was used when teachers have not either explicitly/implicitly explained the meaning (s) of the EWS used, basically no explanation (s) of used EWS.

1.11 Structure of the dissertation

This dissertation contains a total number of six chapters. The main aim of **chapter 1** was to provide the background of the study, highlighting the need to understand the teaching of physical science in rural schools, in particular science teachers' perceptions of and their usage of everyday words used in science context while teaching physical science. Various authors view science education as the key element in addressing issues of social justice, equity and transformation. This view places science teachers at the core of teaching, which includes the importance of teacher's understanding of what science is, the scientific knowledge possessed by teachers and how they teach this knowledge. One of the key elements in teacher's teaching is the appropriateness of the language used in the classroom, in other terms, the use of contextualized science teachers' language. From the reviewed literature, it was unclear as to how teachers (especially rural science teachers) use the contextualized science teachers' language in facilitating or hindering scientific meaning-making. Hence the importance of understanding Grade 10 rural physical science teachers' perceptions of and the usage of non-technical words while teaching physical science lessons. The chapter discussed the rationale for conducting this study, the particular purposes, objectives and also research questions.

Chapter 2 presents a reviewed literature on the role of science contextual language including EWS in teaching and learning physical science. This chapter presents the debates about teaching and learning physical science, and locates physical science teachers' language within science education, by focusing on its role, importance, and the challenges it poses to the users (teachers and learners). The chapter also highlights the complexities in defining rural and rurality in relation to the state of rural education research (internationally, regionally and locally), and the contextual difficulties that science teachers encounter when teaching physical science in South African rural schools.

Chapter 3 discusses the conceptual framework used in this study, particularly the role and importance of mediation, pedagogical link-making and social language of science in this study. This chapter advocates for the relationship in the above concepts for the comprehensive understanding and analysis of physical science teachers' pedagogical practice, especially the use of EWS.

In **Chapter 4,** I present in detail the research process and methods that were used in generating, organizing and analysing the qualitative data for this study. The chapter provides an overview of the study with the presentation of the chosen research paradigm, and how it informs my research design and research approach and the whole study in general. Additionally, I have also discussed the sampling technique and the justification of the sample size.

Chapter 5 presents and critically analyses the findings from teachers' interviews and observed classroom teaching. The research data is analysed in relation to the identified conceptual framework, analytical framework and also in light of the reviewed literature.

In **chapter 6**, I discuss physical science teachers' perceptions of and usage of everyday words in science in relation to reviewed literature, conceptual framework and most importantly the research questions as posed in section 1.8.1. This chapter presents the discussion on the findings and also the meanings of the findings from the study. Chapter 6 also presents a summary of the study's findings and gives directions for future research in relation to the findings of the current study. Finally, this chapter also focuses on the implications of the findings and the researcher's reflections of the influence of language in physical science classrooms within rural schools.

CHAPTER 2

THE NATURE OF SCIENCE TEACHERS' LANGUAGE: A REVIEWED LITERATURE

"Adults may choose to deny it, but children in school know very well that there is a 'language of science'"(Halliday & Martin, 1993, p. 2).

2.1 Introduction

The above quotation by Halliday and Martin (1993) addresses the importance of the existence of and understanding the contextual language used in science classrooms, in order to ensure epistemological access to science concepts. The unfamiliarity and difficulty of physical science make learners understand that science has its own language that needs to be learned to have access to science knowledge. This means knowing that the way of talking in science is different from that used in maths, or in everyday conversations (Halliday & Martin, 1993). Similarly, there is on-going distress internationally, regionally and in South Africa about the poor state of physical science teaching and learning (Mji & Makgato, 2006; TIMSS, 2011; Bilbao-Osorio, Dutta & Lanvin, 2014; Namugaya & Habumugisha, 2017; DBE, 2018), and this challenge seems to be acute in rural and farm schools. The various factors that contributes to the substandard of physical science have been explored (Makgato, 2007; Dhurumraj, 2013) and proficiency in the science contextual language used in teaching and learning science has been identified as one of these factors (Oyoo & Semeon, 2015; Oyoo, 2017). This chapter discusses issues with LOLT and science teaching, with specific attention to the role of language in physical science education, it also locates physical science teachers' language (STL) within science education, by focusing on the role and the difficulties STL, particularly EWS of STL poses to the users (teachers and learners). Lastly, the chapter reviews the teaching and learning of physical science in South African rural schools.

2.2 Issues with LOLT and science teaching

South Africa is one among linguistically diverse countries having 11 officially recognized languages (Probyn, 2005), and the linguistic diversity is also witnessed by teachers in South

African classrooms as most learners learn in English as a foreign language. Of interest is the silences and recognition of linguistic diversity in South African classrooms as English and Afrikaans enjoy the status of being official languages of teaching and learning from Grade 4 - 12 (Department of Education (DoE), 1997; DBE, 2011). Considering the foreignness of English and Afrikaans languages, the majority of South African learners cannot effectively comprehend school knowledge, which relies on proficiency in the language of learning and teaching (LOLT). Research shows that in 2007 there were less than 20% South African learners whose home language is English and Afrikaans (<20% combined), yet about 65% of South African learners are taught in English (DBE, 2010). This confirms English language as the most used language in South African schools as compared to Afrikaans and other nine official languages[9] (Baine & Mwamwenda, 1994; Tshotsho 2013; Khetoa, 2016), despite the fact that most learners in South African classrooms are multilingual[10], speaking English language as their second or third language. Interestingly, this is regardless of the argument by the Department of Education that when learners do not speak the language of instruction, authentic teaching and learning cannot take place (DBE, 2010; DBE, 2011).

Thus understanding the language of instruction as an essential tool for learning is crucial for the learning process in a classroom (Rollnick, 2000), even though, 2nd and 3rd English language speakers are not fully conversant with the language of teaching and learning. The European Union (2015) argues that children without the language of instruction do not reach their potential, and are more likely to leave school early and have lower levels of attainment throughout their schooling. While the influence of language to lower levels of attainment is worrying and could be linked to learner poor performance in South Africa, I argue that without adequate proficiency in the language of instruction, the learning process would be ineffective. The reason being that the language is understood as the means by which a person learns to organize experiences and thoughts (DBE, 2010), and this include teachers as English second language speakers. Research shows that English second language learners *and teachers in some*

[9] "The official languages of the Republic are Sepedi, Sesotho, Setswana, siSwati, Tshivenda, Xitsonga, Afrikaans, English, isiNdebele, isiXhosa and isiZulu" (Brenzinger, 2017, p. 44)

[10] By multilingual, I mean the learners' ability to speak more than two languages or to be proficient in many languages (DBE, 2010).

school contexts (Italics added) struggle with science vocabulary every day (Dlodlo, 1999; Rollnick, 2000), which may lead to poor understanding of science knowledge due to the second language barriers.

Earlier, Gardner (1971) pioneered studies on difficulties with non-technical words of science teachers' language, encouraging more research that investigates students' comprehension of everyday words when used in science context. The focus on language ascribes to Vygotsky's (1978) idea that language is an important tool and play a vital role in the development and formation of concepts, thus linked with the learner who is learning to talk science and the teacher who mediates scientific thought within the ZPD (Rollnick, 2000). So given the use of English as LOLT, it is important that both teachers and learners acquire general proficiency in English language as a necessary first step to effective comprehension of science subject matter knowledge (SSMK) (Oyoo & Semeon, 2015; Mthiyane, 2016). Once English proficiency is established learners need a science contextual proficiency to understand technical and non-technical words of science teachers' language, including contextual proficiency in everyday words that are used in science context (Menon & Mukundan, 2010; Oyoo, 2017).

Similarly, Seah and Yore (2017) argue that during science teaching, learners are learning language (LOLT and STL), learning through language (constructing science ideas using learnt languages), and also learning about language (English and STL cultures and traditions). This means that science teachers have to teach English and STL while teaching about science ideas. Thus considering teachers as mediators of scientific thought, it is important to understand how rural science teachers use language to develop, form and mediate science concepts within their teaching contexts. Thus, given that learning SSMK means that teachers have to teach science contextual language and mathematics[11] (Childs, Markic & Ryan, 2015), learners need proficiency of science teacher's language, a contested issue in South Africa. See Figure 2.1 for the language proficiency issues in science classrooms.

[11] This is not mathematics for solving x but the calculations embedded in the technical terms of science teachers' language. For example, understanding a density of a material through an equation, p=m/v (where p is density; m is mass and v is volume). If a learner is asked about 'stress' of a material then they need to be able to do the mathematical calculations (stress=force/area).

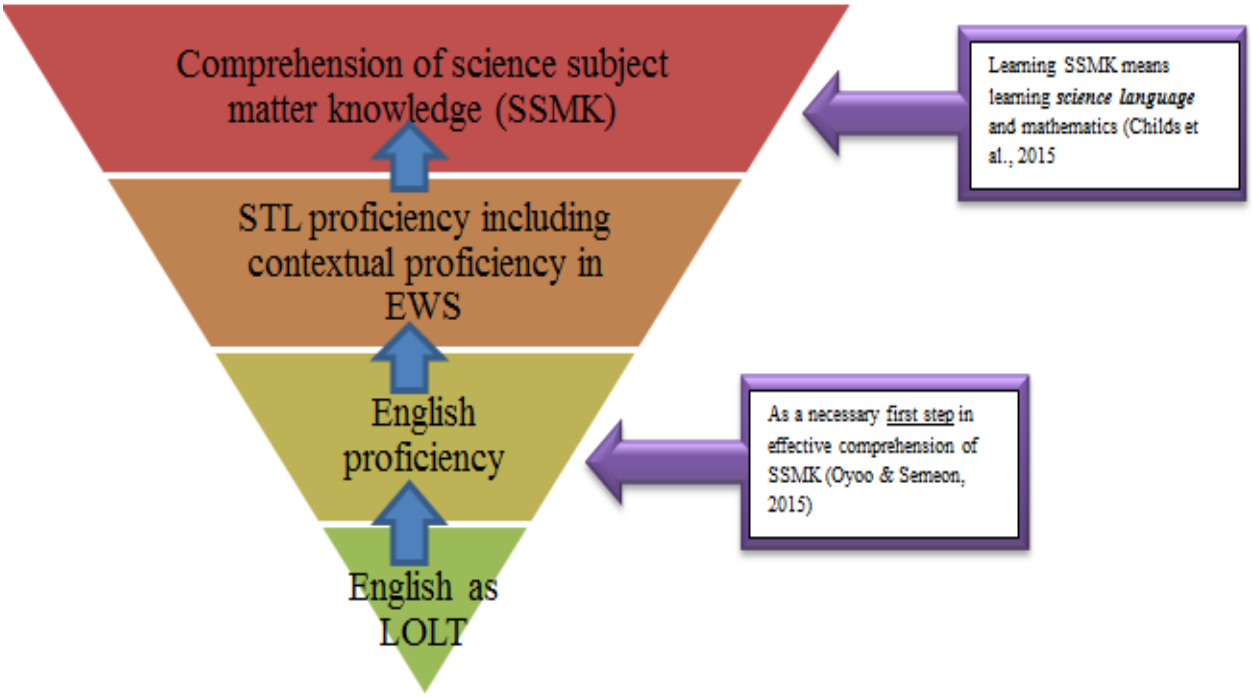


Figure 2.1 Summary of teacher practices on LOLT and its implications for comprehension of SSMK.

2.3 Understanding the role of language[12] in physical science education

Language is a tool that expedites understanding and communication between the science teacher (spoken language), text (written language), and a learner. To reiterate the point, Childs, Markic and Ryan (2015) state that "Almost all teaching and learning takes place using the medium of language, written and spoken" (p. 428), thus when English language is used in a science classroom it takes the contextual scientific form in accordance with science community of practice. McComas (2014) posits that science education has developed its own language with unique entries and general education terms contextualized with respect to science education, although English language is also part of that development. This suggests that science teaching, learning, thinking, and understanding are impossible without the use of English language for this study (Childs et al., 2015), as it plays an important role in concept formation and understanding. Thus, the contextualized science teacher's language links the teacher-scientific ideas to the learner, making it important to critically explore rural physical science teacher's usage of non-

[12] 'Language' as referred to in this study does not mean English language but the science contextual language, unless mentioned otherwise.

technical words in class. Thus the role of English language currently for this study is indisputably central to the cognition and learning process of science (Djite, 2008; Childs et al., 2015), as it determines how the teacher enables or constrains epistemological access[13] to science knowledge.

Lemke (1990) note the link between science language, scientific thinking, and reasoning, accordingly, it is important to gain insight on teachers' perceptions of the role science contextualized language play, specifically the usage of everyday words in science classroom context, in understanding scientific ways of thinking and reasoning. Given the undeniable role of language in effective teaching and learning of science, it is interesting that its role in quality of teaching and learning school science remains under researched in science education research (Oyoo, 2017). Thus science teachers' classrooms are permeated with physical science language that directs teaching and learning, since learning science is learning the language of science (Wellington & Osborne, 2001). The learning of science is influenced by the nature of science teachers' language, which further determines whether science makes sense to the learners or not. The language is also used by science teachers and science textbooks to communicate science ideas, and to convey important concepts, explanations and instructions (Farrell & Ventura, 1998; Ncube, 2014). With the centrality of language in science teaching and learning, it has been a concern that learners fail their physical science examinations not because they only lack science conceptual understanding, instead due to poor understanding of the language in which concepts are questioned (Rollnick, 2000; DBE, 2015, 2018). The physical science failure could also be attributed to the disparities between the language used by the science teacher, external examiner and the language understood and used by learners (Muralidhar, 1991). Considering the role and therefore challenges posed by the use of science contextual language, there is a need to critically explore how science teachers use everyday words encountered in the science classroom context to mediate science knowledge for effective internalization of SSMK by learners.

[13] Epistemological access refers to access to the scientific knowledge that schooling provides, in essence epistemological access advocates for ways of ensuring quality teaching and learning (du Plooy & Zilindile, 2014).

2.4 The teaching and learning of physical science

Science as human enterprise is practiced in the context of a larger culture (religion, philosophy, politics) and its practitioners (scientists and teachers) are the product of that culture (Lederman, Antink & Bartos, 2012). The culture influences how science is understood, interpreted and applied, this further mean that science teachers would teach science influenced by their beliefs, values, behaviours (conscious and unconsciousness), experience, historical background and individual learners' background. Driver et al. (1994) acknowledged the interplay of various factors such as personal experience of the teacher and the learner, language, and socialization in the process of teaching and learning science in the classrooms. So a teacher's and a learner's lived experiences could influence the transition from the subcultures of peers and family into the subcultures of school science, because their social worlds influence the way they make sense of the natural world (Aikenhead, 1996). It is therefore important that science teachers appreciate the multi-faceted subcultures of the learner during the teaching and learning of physical science, because teachers need to make links between learners' everyday understanding of phenomena and scientific ways of understanding the same phenomena that includes the polysemous EWS. The culture of science also addresses the teacher having knowledge about the Nature of Science (NOS), which shapes the implicit and/or explicit teaching of science concepts. Based on the culture of science, everyday words could be used within the Science Community of Practice (SCoP) to explain or describe a phenomenon, while necessitating the contextualization of the meaning of these words in SCoP. Without overlooking SCoP, the focus of this study was to gain insights on rural science teachers' teaching practices including their use of everyday words in science context, which could be influenced by their teaching experience, their perceptions of what it means to teach and understand physical science.

The focus on science teachers is based on the idea that teaching science in school involves introducing learners into the world of concepts, ideas, and understandings that requires a paradigm shift from learners' explanations of the everyday world to science ways of seeing and understanding (Driver et al., 1994; Hodson & Hodson, 1998; Aikenhead, 2003). The teaching also involves the learner constructing scientific knowledge from the mentorship and guidance of a teacher, and not only the teacher transmitting knowledge (Driver et al., 1994; Aikenhead, 2003). In this light, a science teacher should enculture the learner into the scientific discourse,

introducing the learner to scientific ways of thinking and reasoning about the natural world. Accordingly, a science teacher is viewed as an important individual to mediate scientific knowledge for learners, and this includes the explicit explanation and usage of technical and non-technical words during teaching and learning (Vygotsky, 1978; Abd-El-Khalick, 2013). Notwithstanding the importance of a science teacher in a classroom, learners' active participation is as important because they have to learn and understand the discipline social processes that play a role in the process of learning and make meaning of physical science (Stepanek, 2000; St Onge & Eitel, 2017). The social construction of knowledge is based on learner's everyday ontological frameworks evolving from their experience and language use within their specific culture (Driver et al., 1994). They are required to shift from their everyday way of explaining science to the scientific explanation, depending on how a teacher uses science discourse and language while teaching. Additionally, learning physical science involves a conceptual change[14] (Duit & Treagust, 1998), cultural border crossing (Aikenhead, 1996), making it important to understand the contextual nature of science teachers' language usage during classroom teaching.

Moreover, understanding the contextual nature of science teachers' language (STL) is important because the same words might be used by two subcultures (everyday and science contexts), resulting to confusion for the user due to different contextual meanings of the same words used in different subcultures. Apart from the confusion, it is expected that once the language of science is comprehended, learners would think and talk in new ways, since learning science involves learning to think and talk science (Lemke, 1990; Sutton, 1996). Thus learners' confidence in science discourse depends on teacher's effective teaching of science, which relies on understanding the nature of science contextualized language[15], then work out strategies to efficiently communicate science ideas to learners. Oyoo (2011, 2017) refers to the language of science teachers as 'instructional language' of science, which is divided into two broad

[14] The term 'conceptual change' as referred to above denotes learning pathways from learners' pre-instructional conceptions to the science concepts to be learned (Treagust & Duit, 2009). At another level, conceptual change might mean a sharp change of one set of meanings (word meanings), hence the importance of consciousness in contextual nature of science teacher's language.

[15] By science contextualized language, I mean the language used in everyday normal conversation but having a specific meaning when used in the science context (Wellington, 1994; Oyoo, 2009) and language that has science specialized understanding, where outside science context this language has no meaning (Lowe, 2009).

categories: '***technical***' and '***non-technical***' components of science teachers' language. While the technical component includes science discipline concepts (i.e., *kinematics*, *atoms*, *cations*) and everyday words used "as" science words implying new scientific meanings (i.e., *power*, *energy*, *force*), the non-technical component includes logical connectives, metarepresentational terms, and everyday words used "in" science context (Cassels & Johnstone, 1985; Tao, 1994; Oyoo, 2017). Figure 2.2 presents the summary of the science teachers' language and its components.

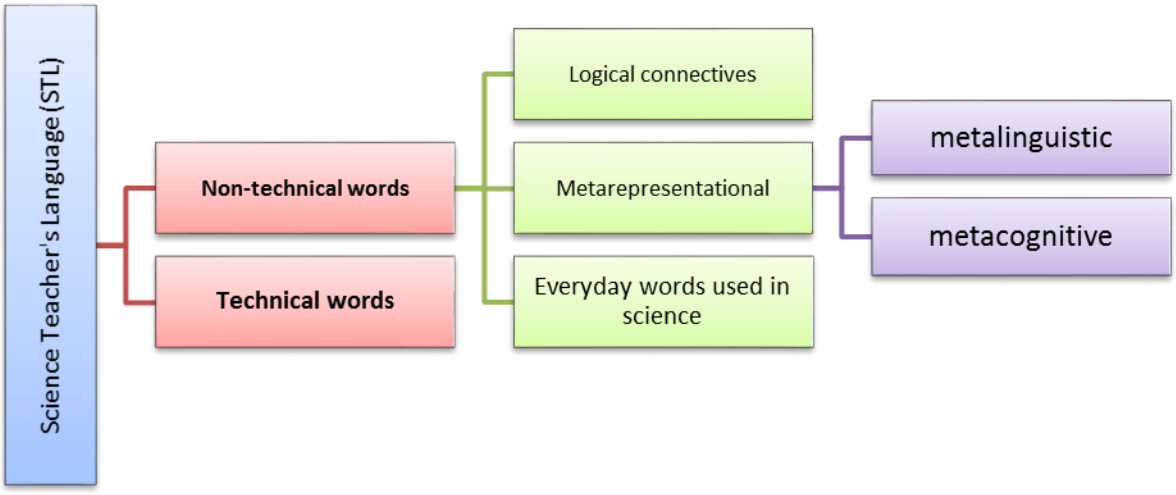


Figure 2.2 Classification of science teachers' language [Adapted from Simelane, 2014]

2.4.1 Technical component of science teachers' language

The teaching of science includes technical component of science teachers' language (Oyoo, 2009), specifically the physical science content knowledge differentiating physical science from other school subjects (Menon & Mukundan, 2010). Science words have triple identity: conceptual, cultural and linguistic (Oyoo, 2012), which represents science concepts, science culture that is distinct from everyday culture, and also science contextual language. Transnational studies view the technical component of physical science as a language component comprising technical words or terminologies specific to a science context, subject or discipline with a more specialized purpose (Gardner, 1980; Menon & Mukundan, 2010; Oyoo, 2012; Childs et al., 2015; Oyoo, 2017). Although old, Gardner (1972) sustained that technical words comprises of physical concepts like names of chemical elements (which could include Neptunium and Einsteinium), processes (which could include thermodynamics and radiation) and apparatus used in the laboratory (which could include rheostat and Erlenmeyer flask). This

means that technical words of science have meanings according to their ascribed functions in the physical science, and their contextual meanings are only known by their users in science community of practice.

Research shows that technical words present problems of familiarity for learners, because they are often complex and difficult to spell and understand for some learners (Cassels & Johnstone, 1985; Wellington & Osborne, 2001; Osborne, 2007; Schoerning, 2014; Childs et al., 2015). Consider for example, words like kinematics, protons, neutrons electrodynamics, isomerism, and radioactivity, these words give cultural, linguistic and conceptual identity to science (Oyoo, 2009; Menon & Mukundan, 2010). Sometimes they make a new language to both teachers and learners, and for learners in rural school who learn in English as a second or third language and complicated by science language and words. It could be argued that some learners in urban and township also experience some challenges with new science language, the difference with them is that if they need extra assistance with science they have different places like universities, science centres like Sci-Bono where they can easily be assisted, which contrary for rural learners. Thus, technical words, for example, cations, genes, capacitance, have ideally one meaning associated with the science specialized meaning, and outside science they have no meaning (Lowe, 2009; Ncube, 2014). Therefore, learning science is learning technical words which give cultural, linguistic and conceptual identity to science and also science learners (Oyoo, 2009).

Hence, the understanding of these words is important for teaching of physical science knowledge, because they define what science is. Scientific language strives to be precise (Bulman, 1985), because words that are used as science words have their own precise contextual meaning beyond the familiar context. However, Bulman (1985) notes that ordinary everyday words that have special meanings in science also confuse learners. These are words like work, energy, and stress, which when used in physical science assumes different meanings from their familiar everyday English meanings (Gardner, 1972; Ncube, 2014; Childs et al., 2015). It is these words that science teachers come prepared to classroom to teach and they define science content and are not the focus of this study, as the current study focuses on the silently ignored non-technical words.

2.4.2 Non-technical component of science teachers' language

The non-technical component of science language plays an important role in science teaching and learners' learning of science content, as it functions as a bridge to learners' understanding or lack thereof of science content (technical component). This component is mostly found in science examinations (instructing learners what to do: some EWS and metarepresentational terms), science textbooks and more importantly in science teacher's talk for meaning-making through logical connectives (one category of non-technical component) (Childs et al., 2015; Ncube, 2016). A physical science teacher's talk serves as the conveyor belt of meanings, instructions, commands, explanations and elaborations during the teaching and learning processes (Ncube, 2014). Thus, the non-technical component of science teachers' language comprises of: '*logical connectives*', '*metarepresentational terms*' and '*non-technical words used in science context*' (Oyoo & Semeon, 2015). The Non-technical words used in the science classroom context also referred to as everyday words when used in science context, consist of words that have become part of the typical language of science subject but have different meanings in their everyday[16] use of a language (Oyoo & Semeon, 2015). Everyday words used in science context (EWS) are associated with the teachers' language as well as the science text, but are not distinct science concepts. This area has received copious research interest, and the current study also focuses on non-technical words, with the special attention to the use of EWS during physical science teaching.

In this research area, words have precise and sometimes different meanings according to their context of use (Cassels & Johnstone, 1985; Oyoo, 2009), and words such as 'sensitive', 'spontaneous', 'contract', 'disintegrate' and others are also used in science classroom and have a special meaning associated with physical science. Understanding the science contextual meanings of these words help science teachers enhance their teaching, and also enable learners' effective learning of science knowledge. Additionally, logical connectives serve as linking words of science teacher's language, as they link sentences or prepositions within sentences or a preposition and a concept (Gardner, 1977; Childs et al., 2015). Logical connectives include inferential words; generalization words; words indicating similarities, comparisons and contrasts;

[16] By 'everyday' meanings, I mean the English standard definition/meaning of words as found in English dictionaries and therefore used by the people in their everyday conversations.

apposition words; and additive words (Oyoo, 2011; 2017; Childs et al., 2015). Furthermore, metarepresentational terms are thinking words used by the teacher and they command learners to think precisely, and are divided into two groups: metalinguistic and metacognitive verbs (Oyoo & Semeon, 2015). With metalinguistic verbs, the science teacher requires learners to "say" which necessitate the understanding of the meanings of, for example, 'define', 'explain', 'distinguish', while with metacognitive verbs, the teacher requires learners to "think", for example 'calculate', 'hypothesize', 'evaluate' (Wilson, 1999). These are some of the key words often used by the science teachers during classroom teaching and also found in science examinations.

2.5 Prevalent difficulties with science teachers' language including EWS

Considering the importance of teacher's awareness of the non-technical during lessons, as mentioned elsewhere in the chapter, research (Cassels & Johnstone, 1985; Childs et al., 2015) shows that technical words present problems of familiarity. The reason is because they are often complex and difficult to spell, pronounce consequently challenging to understand. Failure to understand this component of STL would result to poor performance in physical science; a reason learning science is learning technical words and these words give cultural, linguistic and conceptual identity to science (Oyoo, 2009). Of interest for the current study are the prevalent difficulties that teachers possibly encounter when everyday words are used during physical science lessons. There has been little or no focus on South Africa's teachers' actual usage of these words during teaching, especially physical science teaching in the rural context. One of the challenges with EWS is that they cease to be everyday words when used in science context (Marshall & Gilmour, 1990; Oyoo & Semeon, 2015), making it difficult to understand science knowledge because learners are required to know contextual meanings of each word. EWS often create significant learning problems because learners think they understand them, but do not always comprehend the particular specialized scientific meaning (Hodson, 2009).

It was then interesting to gain insights into rural science teachers understanding of EWS, and how they use (pedagogy) these words during science lessons. It is significant that science teachers are conscientised not only of science content, but also what makes the science content comprehendible, that is, using science contextualised teachers' language including contextualising EWS to help learners make sense of science concepts. Thus, teacher's

consciousness of the language dynamics and understanding scientific meanings of EWS is important, to help learners cross the language border and become users of contextual scientific language. The existing studies have been done to confirm and address learner's difficulties of the language component (Gardner, 1971; Pickersgill & Lock, 1991; Oyoo, 2017), and the current study wants to make a contribution of the rural physical science teachers' voices and experiences of teaching science in rural classroom. For example, Muralidhar (1991) found that students had to cope with their own language, teacher's spoken language, textbook's language, teacher's written language, science terminology (technical words) and the differences between the meanings of everyday words in their everyday context and when used in the science context (non-technical words). The challenge with the non-technical words is that learners often see familiar words and phrases, which are understood with the untenable assumption that both understandings are identical (Cassels & Johnstone, 1985). Tao (1994) affirms that "many students did not correctly comprehend a large proportion of the words, confused them with words that were graphologically or phonetically similar, and even took them for their antonyms" (p. 322). This shows the difficulty of non-technical words and the poor comprehension of contextual meanings of non-technical.

Affirming the difficulty of non-technical words, Ncube (2014), Oyoo and Semeon (2015) and Oyoo (2017), state that everyday words used in the science context pose a difficulty for Grade 10, 11, and 12 physical science learners, while their physical science teachers were rarely aware of the difficulty of these words because teachers never thought learners could have difficulties with 'simple' English words. Bird and Welford (1995) investigated whether learner's performance could be enhanced through simplifying examination paper wording, by comparing UK learners (1^{st} English language speakers) with Botswana learners (2^{nd} English language speakers). They found that UK learners' performance was not affected while Botswana learners' performance was positively affected. This means that after simplification of the wording of each question, the Botswana learners significantly improved their performance (Bird & Welford, 1995). This shows the barrier that English second language speakers are faced with, and simplifying some of the non-technical words could help increase learners' understanding of science content. In addition, the research results and conclusion drawn by Cassels and Johnstone (1985), Greenwood (1990), Muralidhar (1991), and Oyoo (2000) is that, comprehension of non-technical words is irrespective of whether learners are first or second English language speakers.

Within the context of the current study, it is acknowledged that general proficiency in English language is the necessary first step in understanding non-technical words of science (Oyoo & Semeon, 2015), and foregrounds the contextual meanings of non-technical words including EWS. The focus on non-technical words is due to the notion that "Many of the problems of comprehension experienced by students in physics classes arise not from the technical words used but from the non- technical words used" (Marshall & Gilmour, 1990, p. 330), hence the need to understand how science teachers use the problematic words (non-technical) in science classrooms.

Moreover, the study sought to understand, how rural physical science teachers use STL within South African rural schools, whether or not they are aware of any possible difficulties posed by non-technical words to learners, and consequently, what teaching approaches are used by teachers to address the challenges posed by STL. To achieve this, I observed Grade 10 physical science teachers' lessons and their perceptions were navigated through the interviews and also to some extent, their general teaching approach towards STL issues including EWS had implications on their perceptions of EWS.

2.6 Teachers' awareness of learner difficulties with everyday words used in science context

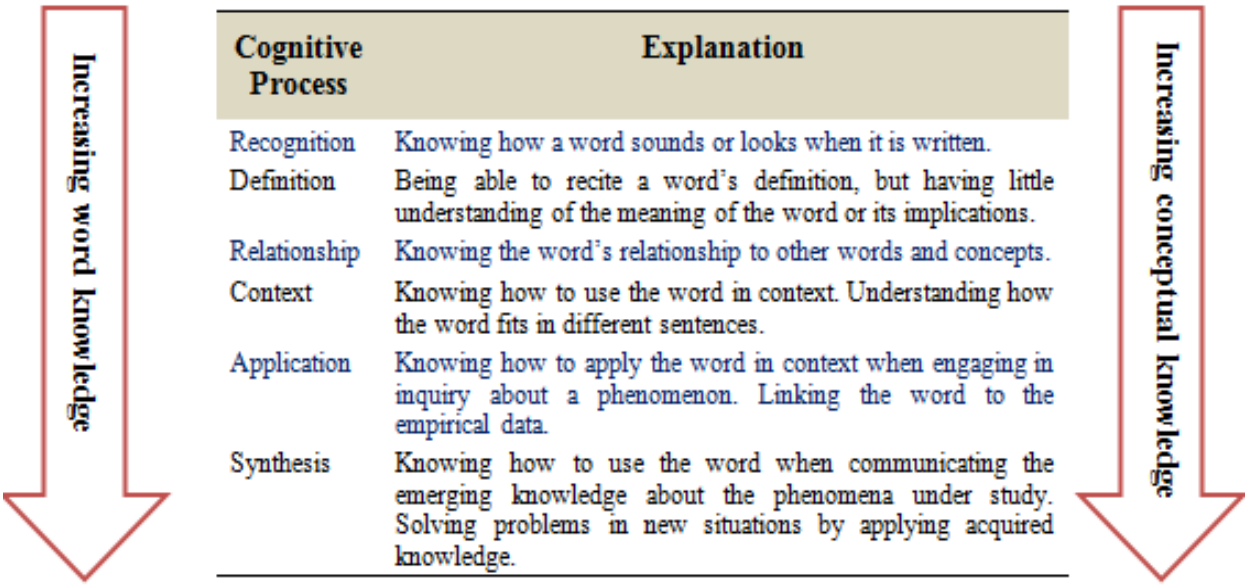
There are very few examples of teachers providing learners with well-constructed explanations of concepts used in science classrooms (Prophet & Badede, 2009). Although, Childs et al. (2015) state that teachers sometimes attend to learners linguistic issues, they do so quite randomly, hence, a need to make science teachers more sensitive to the linguistic issues and to heterogeneity in general. With Childs et al's., (2015) recommendation of sensitizing teachers about the role of language in science classrooms, this study intend to unearth teachers' understanding of EWS, examine whether they are attentive to learners' linguistic challenges in science classrooms and how they teach science content including EWS. This specific focus is because EWS have multiple meanings (polysemy) based on the context in which they are used, and polysemous words present greater challenges because teachers are often not aware that they present a problem. Instead teachers assume common understanding between the learner and the teacher (Childs et al., 2015), thus it is significant for a teacher to "recognize that the problem of language is bigger than just the technical terms and symbols, and to be aware of the areas where

students find difficulty *such as the usage of non-technical words* (Italics added)" (Childs et al., 2015, p. 423).

In as much as research studies (Oyoo & Semeon, 2015; Oyoo, 2017; Seah & Yore, 2017) argue that teachers are unaware of the language difficulty posed by EWS, the current study also exposes the dearth of knowledge in understanding teachers' actual understanding of EWS and also how they attend to science language demand issues in science classrooms. The dearth of knowledge is alarming given that various authors (Oyoo, 2012; Ncube, 2014; Oyoo & Semeon, 2015) posit that more often science teachers are oblivious of the functional value or the difficulty posed by EWS of science teachers' language. Considering the teachers' unawareness of the role played by EWS, it could be argued that science teachers, to some extent, restrain learners' learning of physical science knowledge because, as mentioned earlier, learning science means learning science language and mathematics (Lemke, 1990; Childs et al., 2015). Thus science teachers need to guide learners' realization that "science learning and language mastering cannot be separated because understanding depends largely on language mastering, and that incorrect language unavoidably results in incorrect science" (Mammino, 2010, p. 142). It was the focus of the current study to understand whether science teachers are aware of EWS and how they use language, especially non-technical words, during lessons, do the explain them to learners to make them aware of the different meanings in science context.

2.7 Teacher's mediational approaches to develop word knowledge

Science teachers are expected to explain the different contextual meanings of everyday words when encountered in a science context, so as to minimize the possibility of learners applying everyday meanings to EWS regardless of science context of use (Oyoo, 2011). To do this, teachers should have pedagogical approaches in place to mediate and assist learners' acquisition of appropriate language use, which will enhance the learning, higher order thinking, and understanding of science. Thus, depending on teacher's disciplinary and content knowledge, learners must be taught words in a way that moves them from recognition to contextual use of especially EWS because of their multiple contextual meanings, and to synthesis process of words (refer to Figure 2.3).



Cognitive Process	Explanation
Recognition	Knowing how a word sounds or looks when it is written.
Definition	Being able to recite a word's definition, but having little understanding of the meaning of the word or its implications.
Relationship	Knowing the word's relationship to other words and concepts.
Context	Knowing how to use the word in context. Understanding how the word fits in different sentences.
Application	Knowing how to apply the word in context when engaging in inquiry about a phenomenon. Linking the word to the empirical data.
Synthesis	Knowing how to use the word when communicating the emerging knowledge about the phenomena under study. Solving problems in new situations by applying acquired knowledge.

Figure 2.3 Conceptual knowledge developing alongside an increased level of word knowledge (adapted from Haug & Odegaard, 2014, p. 781)

Additionally, when teaching science, teachers should teach explicitly with the purpose of relating new unfamiliar words to known familiar words (Schoerning, 2014). For example unfamiliar word when teaching chemistry is "halophile" (technical word) which can be brought into known familiar word which is "salt-loving", referring to halophile. At this point, using words that are familiar to learners as a means of familiarizing them to the unfamiliar or foreign terminology of science could help learners gain proficiency in the language of science and build confidence in science content knowledge.

Repetition of words during teaching is also suggested, so that word understanding can at least be kept in the long-term memory of the learner (Schoerning, 2014), in particular during the experimentation process in the laboratory. Another possible approach to teach science is think-pair-share by Haug and Odegaard (2014), to actively involve learners' talking and thinking while learning presented key scientific concepts. Think-pair-share is about giving learners the chance to individually think about a concept before pairing up with a fellow learner to discuss their ideas, and finally share the ideas with the whole class (Lyman, 1981; Haug & Odegaard, 2014). In relation to the current study, physical science teachers could use think-pair-share through giving some EWS to learners to think about and to find meanings of such words in the context of the topic of physical science. Oyoo (2011) suggests signposts factors such as speed of talking

and pronunciation of words, teacher's language and vocabulary level (both technical and non-technical) as significant to initiate learners into science ways of knowing and doing. He further caution that teachers should be careful of the contextual nature of STL during their mediation approaches, because words of STL (EWS and technical words) takes the science contextual meanings when used "in" or "as" science words on top of their already familiar everyday meanings (Oyoo, 2016). Considering that science language is foreign to the majority of learners in Grade 10, this study also intended to observe how physical science teachers help learners to become users of science contextual language.

Thompson and Rubenstein (2000) suggest a teaching approach that explains words according to their origins as an approach, even though it was suggested in mathematics education, it can also help teachers to build learners' science vocabulary, especially in Grade 10 where learners start specializing in physical science and are introduced to science concepts. Sutton (1992) recommends cognitive mapping, whereby a word is hooked onto another and gaining more connections to represent an enrichment of meaning. This teaching approach is important to explicitly show learners' effective building of science vocabulary which necessitates multiple exposures in meaningful contexts. Considering the different presented teaching approaches, it is important to acknowledge that think pair share using word originality and cognitive mapping relies on teacher's disciplinary and content knowledge, which further influence teacher's awareness or lack thereof with language and vocabulary usage during teaching. It is therefore important to gain insight on teacher's perceptions of EWS and the role they possibly play in teaching physical science. In particular when Scott et al. (2011) state that to support science knowledge building, every day and scientific concepts must be linked to integrate and differentiate what is and what is not every day and scientific ways of explaining concepts (Scott et al., 2011).

2.8 Teachers' perceptions of EWS in relation to physical science teaching

The understanding of teacher's perception is valuable and central to practice and educational research, because researchers, teachers, and learners do not usually understand why a person "thought or behaved in a specific way" (Lewis, 2001, p. 272). It is because of this lack of information that conducting research with teachers becomes important, to gain insight of their thoughts and reason for behaving in a particular way. According to Lewis (2001), perception is

"…an understanding of the world constructed from information obtained by means of senses" (p. 274). Similarly, Choy and Cheah (2009) posit that perception should be understood as the process where meaningful information is extracted from physical stimulation. The process of constructing and understanding includes teachers selecting, organizing, and interpreting information about the world into meaningful and coherent picture. Thus physical science teachers (perceivers) could perceive the use of EWS based on the context of the situation in which physical science teaching is taught (Lewis, 2001). Perception is also determined by an individual teacher's teaching and personal experience, intention of teaching science, and rural contextual social needs (Choy & Cheah, 2009). As such Hardre and Sullivan (2008), and Choy and Cheah (2009) posit that teachers' perceptions will influence their behaviours or the way they teach in the classroom. It is therefore important to understand teacher's perception to make sense of the processes involved when rural physical science teachers make meaning of various events and situations in the science classrooms, and even outside the classroom context.

Even though considerable work has been done on the influence of teacher beliefs and experiences in the science teacher classroom practices (Smith, 2005; Mthiyane, 2016), rural physical science teachers' perceptions on the use of everyday words in science context is still an under-researched area in South Africa. Drawing from the science education research that specifically looked at teacher's views or opinions of everyday words used in science classroom context, Oyoo (2017) indicates that most physical science teachers perceive EWS as being 'simple' English words. Consequently, teachers do not expect learners to encounter difficulties with the 'simple' English words such as EWS (Oyoo & Semeon, 2015; Oyoo, 2017), a reason it is important to observe teachers' lessons in relation to their perception. Oyoo (2012) and Mthiyane (2016) contend that science teacher practices is usually based on their initial teacher education training, even if this is the case it is also important to consider that teacher's experiences and perceptions of science teaching and learning can influence their pedagogical knowledge of SSMK.

2.9 Understanding rural education and rural education research in South Africa

Given that the study is located in a rural context, it is important to discuss the complexity of defining rurality as a contested task in research and policy, globally, across and within countries.

Gardiner (2008) argues that the term "rural" is understood differently within the same country, making it problematic to have a fixed definition or generalize rural spaces and their education. The contestation in defining what is rural could be due to the complexity and dynamics of rural areas, especially in South Africa. Internationally, 'rurality' is conceptualized according to the location and population size (McCracken & Barcinas, 1991; Gopaul, 2009), and rural schools are viewed as those located in areas with populations of less than 40,000 people while urban schools are viewed as those located in regions with more than 200,000 people (McCracken and Barcinas, 1991). Gopaul (2009) and Statistics South Africa (2003) described rural areas according to the type of land use (commercial farming), where people farm or depend on natural resources, including the villages and small towns scattered across these areas. Balfour et al. (2008) further state that more often rurality is viewed in terms of isolated space and community, poverty and disease stricken, backwardness and marginalization, rather than focusing on individual experiences of people within their diversified spaces. The foregoing understanding of rural spaces presents a deficit paradigm of understanding rural and rural people, as Moletsane (2012) suggested a move beyond this paradigm.

According to Moletsane (2012), rurality as being viewed only with respect to farming seems to suggest that all rural areas are about farming, and Balfour et al. (2008) associate rural to the dependent relationship between productive capital (agricultural, mining, and manufacturing industries). Masinire, Maringe and Nkambule (2014) propose the acknowledgement of the distinctiveness, agency and strength of rural communities, and encourage researchers to also recognise such power when they engage with rurality. While acknowledging the fluid nature of defining rural areas, this study conceptualizes rurality as a dynamic context where lived experiences of individuals and social issues are related to the rural context (Nkambule et al., 2011). This understanding of rurality ascribes to the idea of space which sustains human existence and development outside the jurisdiction of metropolitan / city / town authority (Masinire et al., 2014). Considering that education does not happen in a vacuum but is influenced by the culture of communities in which it is located, this study also believe that physical science teachers' understanding and use of language during teaching of science could be shaped by factors including among others, teacher training and qualification, teaching experiences, and cultural factors (Adedeji & Oliniyan, 2011). Hlalele (2012) and Balfour (2012) contend that rural

education has intact potential waiting to be explored, a reason this study explored Grade 10 rural physical science teachers' language practices.

2.9.1 The teaching and learning of physical science in South African rural areas

The uniqueness of rurality and rural education necessitates the recognition of the socio-economic background of learners, availability of qualified physical science teachers (inadequate teacher training), science literacy levels, and learners' and teachers' cultural differences. Physical science is viewed as a practical subject (Oyoo, 2012); a reason practical work plays a major role for effective teaching, learning and appreciative of physical science. The practical work is perceived as an essential aspect in understanding science knowledge (Legari, 2004), even though the availability of science apparatus for practical work is unfortunately scarce for many rural schools (Muwanga-Zake, 1998; Gardiner, 2008). The challenge of practical work is acute in rural schools because of the lack of science laboratories and other materials for science practical work, even though challenges with practical work is also registered for some township and even some urban schools.

In rural schools where science laboratories are available they are mostly used as storerooms (Muwanga-Zake, 1998; Legari, 2004) or additional classrooms (Nkambule et al., 2011) instead of operational science laboratories, due to lack of equipment provision. Unlike rural schools, most urban schools enjoy equipped science laboratories, more qualified and experienced teachers, and learner's link theory and practice by continuously conducting practical experiences that contribute to improved student performances (Muwanga-Zake, 1998). Almost two decades Muwanga-Zake (1998) noted that "Most of the scientific approaches and content favours urban settings more than rural settings" (p. 150), and of concern is that 24 years of democracy rural physical science teachers' voices, experiences and teaching approaches continue to be marginalised. Physical science education researchers have popularised urban knowledge, with the acknowledgement of convenience, and overlooked that including disadvantaged knowledge address issues of social justice. In the absence of practical work, teacher's language (spoken or written) becomes a major tool for teachers to mediate scientific knowledge.

This study further acknowledges that a 'one size fits all' approach to education policy and its implementation makes it possible to overlook and disregard important aspects of the lives and needs of rural communities (Gardiner, 2008). For example, when teaching science in rural schools, science teachers encounter various challenges which include (but are not limited to) lack of electricity, libraries, computers, laboratories, teachers having challenges with speaking English and therefore opting for vernacular languages as LOLT, and over-crowding of classrooms (Muwanga-Zake, 1998; Legari, 2004; Gardiner, 2008). In relation to physical science, Muwanga-Zake (1998) further argues that science textbooks and teacher's talk are not easily comprehended by rural learners, as they are written in English which is not a first or second language to the majority of learners. This study focuses on rural context with the assumption that rural high schools are exposed to unique experience and challenges while teaching and learning physical science, as compared to their township and urban counterparts. It is important to mention that the current study is not comparative in nature, but use comparative language to show the current different education and schooling experiences.

2.10 Chapter summary

This chapter discussed issues with LOLT and science teaching with specific attention to the role of language in physical science education, it also located physical science teachers' language (STL) within science education, by focusing on the role and the difficulties of STL, particularly EWS of STL poses to the users (teachers and learners). What emerges from literature is that issues of specialized or contextualized language of science are largely established and agreed upon, and that most science learners encounter difficulties with non-technical words, especially EWS, despite their general proficiency in English language. What was more alarming from literature is that little is known about science teachers' understanding and actual usage of non-technical words, including EWS during teaching in rural schools and rural teacher's voices have been overlooked by science education researchers in South Africa.

To give context to the study, the chapter reviewed the teaching and learning of physical science in South African rural schools with the focus on the contextual difficulties that science teachers encounter when teaching physical science in South African rural schools of South Africa. Most studies in science teachers' language presume that urban and township findings can be generalized to rural schools' context, a possible reason that little research has been done in such

a context. The over focus on township and urban schools overlooks the unique contextual factors that are embedded in rural contexts. Various authors posit that rural people and their knowledge, skills and ways of doing things tend to be homogenized, disregarding various lived experiences of individuals within and across rural spaces. Hence the idea of moving beyond homogenizing rural spaces and rural people (Balfour et al., 2008). Within rural areas, there are multifaceted factors that influence the teaching and learning of science, and these factors might shape the effectiveness of science teaching and learning.

CHAPTER 3

CONCEPTUAL FRAMEWORK

3.1 Introduction

Given that chapter 2 reviewed literature on science teachers' language, in particular teachers' use of everyday words in science classroom context and also contextualised the study within rural education, this chapter expands on the conceptual basis of the study. While conceptual framework is sometimes referred to as theoretical framework, these terms are neither interchangeable nor synonymous (Grant & Osanloo, 2014), and this study used a conceptual framework as a lens to understand and evaluate the nature of rural Acornhoek physical science teachers' usage of EWS during teaching. Conceptual framework means "…a skeletal structure of justification, rather than a skeletal structure of explanation based on formal logic (i.e., formal theory) or accumulated experience (i.e., practitioner knowledge)" (Eisenhart, 1991, p. 209). The conceptual framework offers a logical structure of connected concepts that help provide a picture or visual display of how ideas in this study relate to one another, and also showing how the connections will be appropriate and useful given the research problem under investigation (Lester, 2005; Grant & Osanloo, 2014). This study is informed by Vygotsky's (1978) concept of mediation, Scott, Mortimer and Ametller (2011) concept of pedagogical link making focusing specifically on the first form: pedagogical link-making to support knowledge building. Context is important in this study as Halliday (1978) writes, "[t]he context plays a part in determining what we say *and how we say it*; and what we say *and how we say it* plays a part in determining the context" (Italics added) (cited in Wells, 1999, p. 8). It is thus significant to understand how cultural historical contexts affect science teachers' language use, but also take into account the intricacy of the contexts within which teachers use the target science language, and specifically the everyday words use in science lessons.

Vygotsky's socio-cultural theory

Considering that this study used selected concepts from the Vygotskian's socio-cultural theory, it is important to briefly explain the nature of the theory. A basic goal of sociocultural theory is to create an account of human mental processes that recognizes the essential relationship between

these processes and their cultural, historical, and institutional settings (Topçiu & Myftiu, 2015). So although a primary interest of a sociocultural theory is human mind (development of human mind), the theory attempts to provide accounts of human mind through processes that the human mind adopts (Kyungsoon, 2000). For this study a sociocultural theory of teaching and learning science study the mental processes and activities primarily at the social level, by conversing with teachers and observing their teaching as they mediate science knowledge. Thus teaching cannot be explained without the examination of social interactions that the human makes. Although the learning process is generally considered to be very individualistic, for sociocultural theory learning takes places not at the individual level but at the social level.

3.2 Mediation

The view that science represents a uniquely valid approach to knowledge, disconnected from social institutions, their politics, and wider cultural beliefs and values has been strongly challenged in science education research (Shapin & Schaffer, 1985; Lemke, 2001). Considering this, the study used sociocultural theory which emphasizes the interdependence of social and individual processes in the co-construction of knowledge (John-Steiner & Mahn, 1996), making the process of science teaching and learning social events. The purpose of the classroom social event is to enculturate the novice learner into science ways of thinking and doing, where a science teacher scaffolds science knowledge by modelling practices of physical science through the appropriate ways of using specific and contextualized science teacher's language (STL). Thus, mediation is important for this study to understand the taken for granted assumptions that physical science teachers' knowledge and language use are influenced by interrelated factors such as: social interactions, cultural background of the teacher that influences perception of science, the learner and school, and the community at large, which may shed light into teaching practices within rural schools. This study does not assume that science teachers in rural environment lack understanding of science teacher's language, rather, it aims to gain insights into how, within rural environment, science teachers use science language to mediate science knowledge and concepts.

Mediation is a process of using language to regulate social and mental activity during teaching and learning processes (Harvey, 2011), and knowledge is mediated through culturally constructed means (language as a psychological tool) (Lantolf & Thorne, 2006).The process of

mediation is vital in teaching because teachers have to mediate science knowledge using tools such as symbolic cultural artifacts—signs, symbols, texts, formulae, and most fundamentally, language (Vygotsky, 1978; Karpov, 2003), which carries the school science culture (Mortimer & Scott, 2003). For teachers to mediate science knowledge they must have internalized it including the general usage of language, especially awareness of EWS use while teaching to make learners conscious of the different meanings in and outside science context. This study used mediation to explore relations between the teaching practice and the understanding of teaching tools such as the science teachers' EWS, the semiotic (language) mediation during physical science teaching and learning (John-Steiner & Mahn, 1996; Harvey, 2011). Thus the role played by science teacher's thought, perception and language during teaching are essential aspects of this study, to understand whether teachers are aware of the non-technical words they use while teaching in relation to their perceptions of EWS.

Martin and Dean (1964) categorized mediation in word teaching as implicit mediation, explicit mediation and non-mediated. Wertsch (2007) views mediation as explicit when

> …an individual, or another person who is directing this individual, overtly and intentionally introduce a "stimulus means" into an ongoing stream of activity…it is explicit in the sense that the materiality of the stimulus means, or signs involved, tends to be obvious and nontransitory… (Wertsch, 2007, p. 180).

In contrary to the explicit mediation is implicit mediation which is less obvious and therefore, more difficult to detect as it includes the inner speech in mediating human consciousness (Wertsch, 2007). Implicit mediation is not necessarily introduced intentionally during the ongoing teaching; instead it happens unconsciously when teachers are focusing on presenting the concepts. In the absence of intentional introduction of stimulus means and the mediator is unconscious of some stimulus means, hence not even making it less obvious, there is no mediation (non-mediation) of especially meanings of EWS (Martin & Dean, 1964). Considering the different mediations, teachers mediate science knowledge consciously or unconsciously using some or all mediations, a reason is important to observe teacher's lessons to understand how they mediate EWS. Implicit mediation is understood as teaching segment where teachers explain EWS unconsciously without verbalizing the meaning of the used EWS, instead explaining the meanings of EWS is embedded in the classroom teacher talk. Lastly, non-mediation is observed when teachers have not either explicitly or implicitly explained the meanings and use of EWS in

different contexts. It was therefore important to understand how a teacher mediates knowledge and concepts using EWS of STL, because effective and appropriate language use could successfully lead to learners' learning and understanding of scientific concepts.

Drawing from Thorne, Gericke and Hagberg (2013) study, they suggest that teachers should be conscious of either technical or non-technical words used and must explicitly explain the closely related words with different meanings. The assumption is that, if teachers explicitly mediate word usage during teaching, learners might be able to internalize the mediated knowledge for effective comprehension of science content knowledge (Oyoo, 2014). Mediation of science concepts and making sense of everyday words use address the nature of social interaction between the teacher and a learners, to develop learner's knowledge intrapsychologically and interpsycholgically (Topçiu & Myftiu, 2015). Oyoo (2014) suggests that both technical and non-technical words require special attention during teaching, because of the prevalent difficulties with these word categories. Additionally, Wellington and Osborne (2001) argue that it is not just about language, but about what science teachers do with the language, whether they are aware of the selection of words they use while teaching science considering the complexity of everyday words use.

In addition, it was important for this study to recognize that individual teacher's teaching experiences are shaped by the beliefs about science knowledge, the nature of training and the quality of content knowledge. Accordingly, given the context of the study, it was important to understand the teaching of science that happens in rural schools, in relation to the teacher's awareness and explanation of EWS usage during lessons. Mediation links social and historical processes (Wertsch, 2007), by viewing human activities (science teaching) as taking place in cultural contexts and are mediated by language (John-Steiner & Mahn, 1996). The discussion on chapter 2 has shown the importance of language in the teaching and learning of science, similarly for mediation, language plays an important role in the teaching and learning as it mediates the transition from the interpsychological[17] to intrapsychological[18] planes. Thus mediation helped to

[17] Interpsychological plane means the process involving small groups of individuals engaged in concrete social interaction and are explainable in terms of small-group dynamics and communicative practices (Wertsch, 1985).

[18] Intrapsychological plane means the development or learning that happens within the individual, voluntary attention, logical memory, the formation of concepts, and development of volition usually occurs (Wertsch, 1985).

understand the role played by teachers' usage of language while teaching and constructing scientific knowledge, in particular how teachers use EWS to facilitate science knowledge. Vygotsky believes that external influences, such as teaching context, teacher experiences for this study, cognitively transform individuals' interpretation, perceptions, and meaning of the external world (Vygotsky, 1978; Phan, 2012).

For the process of mediation, the teacher engages with concepts for meaning-making, and these include everyday or spontaneous[19] and scientific concepts (Vygotsky, 1978). While everyday concepts are immediate, unsystematic, and contextual because they emanate from day-to-day lived experiences of individuals, scientific concepts are decontextualized from lived reality, only exist as word meanings and are mediated towards its object (Vygotsky, 1986; Lantolf & Thorne, 2006; Harvey, 2011). Although everyday concepts and scientific concepts are distinct, they interact because everyday concepts are sometimes used in school science as scientific concepts, and this relation is viewed as a pre-requisite for the development of higher order thinking skills (Harvey, 2011), given explicit mediation of EWS. The understanding of science content knowledge needs a teacher or learner to move beyond the everyday meanings of everyday concepts, towards scientific meanings of the everyday concepts when used in science context (Mortimer & Scott, 2003; Scott et al., 2011). Important also, is that Vygotsky's concept of 'scientific concepts' do not refer to science specific concepts but historical and linguistic issues of a particular discourse which comes after being taught (Kozulin, 1990; Scott et al., 2011). Unlike everyday concepts which are experientially rich but unsystematic and highly contextual (Kozulin, 1990), scientific concepts form a coherent, logical, and hierarchical system (Daniels, 2007; Harvey, 2011). In the context of this study, everyday concepts would present everyday words in the science context (contextual English words) and scientific concepts would present the technical words of science (science discourse).

According to Vygotsky (1978), a teacher is a knowledgeable other who does not just transmit knowledge but mediates science knowledge. During the mediation of knowledge, science contextualized language is used as a meditational tool, even though this language is not the only

[19] Both terms 'everyday' and 'spontaneous' are used interchangeably by most researchers in the sociocultural research field (Wertsch, 1985; 1998; Harvey, 2011) but this study will use only the term 'everyday concepts' to also refer to spontaneous concepts according to Vygotsky's work.

semiotic system to be used in order for learners to make sense of science but teachers can also integrate representations (practical work, symbols including equations, visuals such as graphs, pictures, and diagrams). The integration of semiotic systems subscribe well to Lemke's (1998) idea of drawing teachers' attentions to various but connected semiotic modalities such as language, representations (practical work, symbols including equations, visuals such as graphs, pictures, and diagrams) when teaching a concept. Mediation is foregrounded, because the purpose is to understand teachers' knowledge of science teachers' language (STL). Mediation argues for language as a conceptual tool which helps shape thinking (Harvey, 2011), which means teachers should explicitly and effectively use science contextual language to develop learner's conceptual understanding of science and ability to think in new ways and talk science. Mercer (1995) also posits that teaching and learning is about learning to use language to represent science ideas, to interpret experiences, to formulate problems and to solve them.

3.3 Social language of science

As argued in chapter 2, teaching science involves introducing learners into the science contextualized language, science concepts, conversions, laws, theories, principles and ways of talking and working of science (Lemke; 1990; Mortimer & Scott, 2003). The basic tools of science such as science contextualized language are developed within scientific community of practice to mean specific things in science context. To exemplify this, consider the language used by a solid state physicist in talking about the structure of ceramic materials which forms part of one social language (language specific to science context) and the language used by a potter in talking about moulding properties of the same ceramic materials which forms another part of social language (Mortimer & Scott, 2003). So the social language of school science introduced through the school curriculum could be thought of as a tool (Vygotsky, 1978), offering a distinctive way of talking and thinking about the world (Lemke, 2000). Besides the social language of school science, individual human beings are immersed in everyday social languages and these languages provide means for day-to-day communication with others (Mortimer & Scott, 2003). So particular words of social language could be understood and used differently in the context of school science (Brown, Collins & Duguid, 1989).

Given the differences between the everyday social language and the social language of school science, it is important for science teachers to be aware of this difference and then explicitly point it out to their learners during science teaching because "if the science teacher presents these ideas as if they are obvious, then they are doing the learner a disservice" (Mortimer & Scott, 2003, p. 15). Then, the role of the science teacher, among others, includes introducing learners into the social language of science, specifically to the contextual nature of familiar everyday words often used in the social language of science.

The introductions should be done such that familiar English words used in science classrooms are explained because meanings of these words are inherited from their context of use (Brown et al., 1989). Resonating the contextual nature of words, Mortimer and Scott (2003) posit that "… words are inevitably polysemous, acquiring different shades of meaning as the context of usage changes" (p. 11). Although, Mortimer and Scott (2003) refer to technical words of science classrooms such as energy, force, mass but also mentioned the non-technical (EWS) such as substance, reaction, and living, because all the above words can signify different things for teachers and learners, hence the principle of polysemy which applies to all the discussed words. Given the polysemous nature of especially non-technical words, it is important that teachers explicitly explain the contextual meanings of word usage in science classrooms.

The importance of explaining word usage for conceptual understanding stems from the idea that:

> *…Almost all of what we customarily call 'knowledge' is language. Which means that the key to understanding a subject is to understand its language… what we call a subject is its language. A discipline is a way of knowing, and whatever is known is inseparable from the symbols (mostly words) in which the knowing is codified… If all the words that biologists use were subtracted from the language, there would be no biology…This means, of course, that every teacher is a language teacher. …We mean…teachers, quite literally, have little else to teach but a way of talking and therefore seeing the world.* [Postman & Weingartner 1971, p.103]

Echoing the similar point, Brown et al. (1989) assert that "all knowledge is, we believe, like language" (p. 33). The above quotation from Postman and Weingartner (1971) acknowledges the interrelation between words, language and knowledge, that knowledge is language but if all the words were subtracted from language then there would be no knowledge. Similarly, in science education, Oyoo has acknowledged the triangular relationship between *'words, language* and *knowledge*' (Oyoo, 2012; 2017). Tao (1994), Mayring (2014), and Oyoo (2017) suggest that words have different meanings according to their context of use, and to understand physical

science it is significant to understand the holistic nature of science language used in science classroom contexts. Similarly, Glasersfeld (1992) argues that science learning "for every single individual it begins with the meaning of words and phrases" (p. 5). Postman and Weingartner (1971) views '*words'* as the components of '*language'*, where language acts as an umbilical cord between the knowledgeable other (teacher) in negotiating science '*knowledge'* to the novice (learner) who has to comprehend negotiated knowledge through language use (Brown et al., 1989).

The preceding discussion on words, language and knowledge, gave rise to this study to understand physical science teachers' teaching approaches, and whether they are aware of EWS difficulty they use during science teaching. Understanding science teachers' language use from the teachers' perspective is of necessity because research (Oyoo, 2012: Ncube, 2016; Kurwa, 2016; Oyoo, 2017) indicate that as much as physical science learners fail to differentiate and correctly apply the meaning of words in their context of use, some science teachers are also not aware of such language difficulties. Considering the lack of awareness, this study intended to explore whether rural physical science teachers are conscious of such difficulty, and understand the way they use EWS while teaching physical science. The relation of words, language, and knowledge is represented diagrammatically in Figure 3.1.

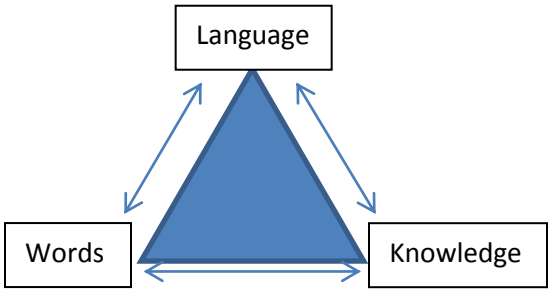


Figure 3.1 Triangular relationships as described by Oyoo (2009; 2017).

Figure 3.1 indicates that teacher's understanding of scientific knowledge would be influenced by their codified specific meanings of words, as dictated by the nature of science and the context in which the everyday words are used (Kurwa, 2016). This means that science concepts are possibly not fully understood until they are represented in words (Tao, 1994) signifying language, while words are also crucial in knowledge construction and development. The triangular relationship acknowledges that words of science teachers' language hold with them

science meaning which is always inherited from the context of use (Brown et al., 1989). Therefore relationship between words, language and knowledge justifies the view that science is a language on its own (Wellington & Osborne, 2001) and until it is represented in words, its knowledge would remain undiscovered.

3.4 Pedagogical Link-Making: To support knowledge building

When teaching and learning physical science concepts, knowledge has to be built such that there are connections between concepts, and the distinction between every day and scientific ways of explaining are explicitly highlighted (Mortimer & Scott, 2003). This is fundamental to science learning because both teachers and learners need to make links between existing science concepts and their contextual meanings, and new concepts with their contextual meanings. To advance the idea of concept connections, Scott et al. (2011) posit that Pedagogical Link-Making (PLM) is concerned with ways in which teachers and learners make connections between ideas and concepts in the ongoing meaning-making interactions during classroom teaching and learning. PLM argues for a teacher to scaffold and guide learners in the comprehension of new knowledge for scientific understanding (Driver et al., 1994; Mortimer & Scott, 2003). As such, the depth of understanding science concepts and their contextual meanings depends on the depth of links as organized by the science teacher (Scott et al., 2011).

PLM requires high and appropriate science teacher content knowledge in order to successfully make science conceptual links (Scott et al., 2011). Mortimer and Scott (2003), and Scott et al. (2011) identified three forms of link making which includes links to support knowledge building, links to promote continuity, and links to encourage emotional engagement. This study focused on link making to support knowledge building and highlights the importance of connections between different kinds of knowledge, including everyday knowledge of words to assist learners develop a deep understanding of the subject matter (Scott et al., 2011). There are 6 approaches that can be used to support knowledge building which are: making links between every day and scientific ways of explaining; making links between scientific concepts; making links between scientific explanations and real world phenomena; making links between modes of representation; moving between different scales and levels of representation; and analogical link making. However, this study only focused on making links between scientific ways of explanations and everyday ways of explaining, and on analogical link making.

3.4.1 Approach 1: Making links between every day way of explaining and scientific ways of explaining

According to Scott et al. (2011) science learning inevitably occurs against a background of everyday/spontaneous ways of talking and thinking about phenomena. In some areas of learning there might be an overlap (or similarity) between the everyday and scientific ways of explaining and in other areas they might be quite different. The effective understanding of science is associated with the depth of links made by the teacher during teaching, including making links between everyday word usage and science word usage (Scott et al., 2011). In places where there is an overlap between meanings of a word, teaching involves making links to integrate the scientific way of explaining with every day words, and where there is a difference in meanings of words, teaching involves making links to differentiate the scientific way of explaining from everyday views (Scott et al., 2011). In making links between scientific concepts, a teacher recognizes how the scientific concepts fit together in an interlinking system, because the usefulness of concepts comes from their connections to one another for a concept system to be developed (Scott et al., 2011). The nature of explanation is fundamental in teaching generally, and making links between scientific explanations and real world phenomena requires teachers to be knowledgeable about the subject and its relationship with the real world (Scott et al., 2011).

Even though Scott et al.'s (2011) concepts of differentiation and integration refer mostly to everyday words used as science concepts (energy, speed, heat), their concept of differentiation and integration is equally applicable also to everyday words used in science classroom context. The teacher's differentiation and/or integration of EWS meanings are critical because learners link the everyday words into hierarchical systems of school science conceptual knowledge leading to a deeper understanding of science content knowledge (Mortimer & Scott, 2003). Figure 3.2 shows diagrammatically integrating and differentiating ideas.

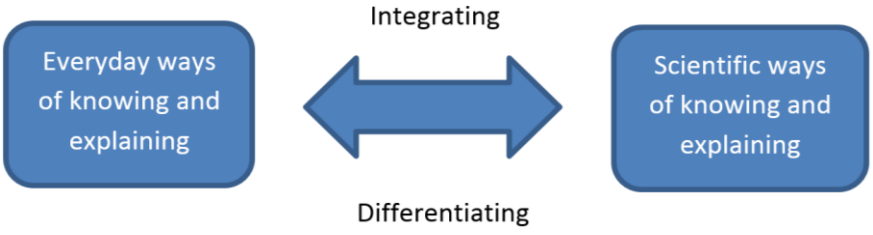


Figure 3.2 Intergrating and differentiating everyday and scientific views (Adapted from Scott et al., 2011, p.7).

3.4.2 Approach 2: Analogical link-making

Some teachers use familiar and known analogies to effectively explain scientific concepts. Likewise, in this study there were some teachers who used analogies to explain both the technical and the non-technical words of science teachers' language. Basically, the teacher assists learners to understand the scientific concepts through the use of known and relevant analogies. The use of relevant and adequate analogies during teaching also helps to build science knowledge from what learners already know. The use of analogies is beneficial for teaching both technical and non-technical words including EWS. Analogies are effective in teaching science but when used careful thought must be applied in selecting and teaching with analogies. One of the cautions to be considered by teachers is making known the short comings of an analogy as it may propagate the development of alternative concepts (Dagher, 1995). As argued further by Dagher (1995) analogies may bring conceptualisation of knowledge in learners but, if not well chosen and when its short comings are not explained to learners, it may mislead learners. In light of this view of Dagher, some rural physical science teachers did not make clear the intentions of their chosen analogies and the individual concepts demonstrated through the used analogies were not explicitly explained. This might have, in some cases, proved the analogy to be useful in having the idea of what the teacher would have been talking about but not enhanced comprehension of specific concepts taught.

3.4.3 Communicative Approaches

Teacher talk and learner talk has been categorized into four communicative approaches (Mortimer & Scott, 2003; Scott et al., 2011). These four categories distinguish between the interactive and non-interactive talk during teaching. The teacher talk is interactive when involving the participation of the teacher and learners and non-interactive if only involving the participation of the teacher. Moreover, interactive and non-interactive talk can be dialogic and/or authoritative. Dialogic communication involves the teacher and learners paying attention to more than one point of view, more than one voice is heard and there is exploration or interanimation of ideas, while authoritative communication involves focussing on one point of view, only one voice is heard and there is no exploration of different ideas (Scott et al., 2011). Table 3.1 shows the four categories of communicative approaches as being interactive-dialogic / interactive authoritative or non-interactive-dialogic / non-interactive-authoritative communicative approach

and also describes each approach. These approaches would help unearth strategies that teachers use during classroom teacher talk and possibly uncover teacher's use of language in differentiating and/or integrating between everyday meanings of EWS.

Table 3.1 Four categories of communicative approaches used in classrooms (Adapted from Scott et al., 2011, p.19)

Communicative Approach	Description
Interactive/dialogic	The teacher seeks to elicit and explore students ideas about a particular issue
Interactive/authoritative	The teacher leads students through a sequence of instructional questions and answers
Non-interactive/dialogic	The teacher is pulling together and presenting students ideas and also drawing attention to the differences between everyday and scientific points of view
Non-interactive/authoritative	The teacher is presenting a specific point of view.

3.5 Chapter summary

Vygotsky acknowledges the primary importance of talk in social situations as a necessary first step to the individual learning; however, this study advanced the importance of talk by examining in detail the teacher talk of the science classroom, particularly the use of EWS of STL, seeing how it might underpin effective teaching (Vygotsky, 1978; Mortimer & Scott, 2003). This chapter discussed Vygotsky's concept of mediation and Scott et al.'s concept of pedagogical link making in relation to the study. Language is a mode of communication used to mediate science content and contextual meanings of the science text (Lindkvist, 1981; Tesch, 1990; Hsieh & Shannon, 2005). The contextual language of science is composed of words that have science specific meanings, which differs from the everyday meanings of the words (Mayring, 2014; Oyoo, 2012). Importantly, the word understanding is crucial in science conceptual understanding (Haug & Odegaard, 2014) because words are components of language and language is knowledge of the content (Brown et al., 1989). Thus, in the context of this study, mediation views science teachers as the knowledgeable others (Vygotsky, 1978) who should be aware of difficulties with language issues (including difficulties with EWS) (Oyoo, 2017), while mediating both the technical and non-technical words of STL. The combination of mediation and PLM allowed this study to gain an in-depth understanding of teacher's use of everyday words used in science classroom contexts. Mediation also assisted this study to understand the factors that shape science teacher's understanding and therefore teacher's pedagogic approaches to EWS during science lessons, which means mediation helped give context to which STL including

EWS are used. All the aspects of the conceptual framework (mediation, PLM, and social language of science) were important for this study due to the different methodological and analytical roles they played.

CHAPTER 4

RESEARCH METHODOLOGY

4.1 Introduction

Research is viewed by Leedy and Ormrod (2010) as a process through which information about a particular phenomenon is given meaning based on the focus of the study. Echoing this view, Creswell (2012) defines research as a process of steps used to collect and analyse information to broaden our understanding of a particular phenomenon, which help to deconstruct and reconstruct the prevailing theorizations of the subject under scrutiny based on new discovered information. This chapter presents the processes of this study which includes the research paradigm, research design, research approach, research methods, data analysis tool that were chosen to help address the objectives of the study. In addition, ethical considerations and techniques to address issues of trustworthiness of the findings are also highlighted towards the end of the chapter.

4.2 Research paradigm

Research paradigm refers to the entire system of thought, the well-recognized research traditions in a specific discipline (Mouton, 1996), or a philosophical framework. Paradigm gives epistemological and ontological stance for the study, making it important to identify a research paradigm which exposes the researcher's philosophical and ontological standpoints about what constitutes beliefs, values, reality and knowledge. Henning (2004) considers positivism, critical, and interpretivism as three principal paradigms in social science research, because of their individual underlying philosophical assumptions of the world. Positivism subjects human behaviour to rules and views it as something experimental, hence positivism was not relevant for this study because it defines life in measurable terms rather than inner experience, and excludes notions of choice, freedom, individuality and moral responsibility (Cohen, Manion & Morrison, 2011). While critical paradigm focuses more on the relations between power and political nature of society rather than interpreting human behaviour (Pozzebon, 2004; Cohen, Manion & Morrison, 2011), interpretivism recognizes humans as individuals having unique experiences and

uses descriptions to interpret meanings of individuals, hence this study used interpretivism as the working paradigm.

Interpretivism served as organizing principle to which reality was interpreted in this research study (Pozzebon, 2004; Morgan, 2007; Babbie, 2011). Thanh and Thanh (2015) argue that interpretive paradigm allow researchers to view the world through the perceptions and experiences of the participants. Ontologically, interpretive paradigm argues that all observation is both theory-laden and value-laden and investigation of the social world should be the pursuit of a subjective truth, and epistemologically, interpretive paradigm argues that our knowledge of reality is a social construction by human actors (Burrell & Morgan, 1979; Leitch, Hill, & Harrison, 2010; Ponelis, 2015). In line with the conceptual framework, analytical tool (PLM and qualitative content analysis), interpretive paradigm considers an understanding of the context in which any form of research is conducted as critical to the interpretation of data gathered (Thanh & Thanh, 2015). The purpose of this study is to understand and interpret everyday teaching of science in the classrooms (teaching practice), teacher experiences of science and the culture of the school, as well as teachers' thinking and awareness of the usage of EWS while teaching (Rubin & Babbie, 2010).

As an interpretivist researcher, the teaching of science is subjective, because it is shaped by the social realities and teacher perceptions of EWS. In addition, Doolin (1998) argues for interpretive researchers to consciously adopt a reflective stance in understanding the role that STL plays in teaching and learning science. Considering the above discussion, were able to reflect on their teaching practices and use of EWS while teaching through interviews, and some paid attention to language issues in their teaching practice, representing the power of reflexive interpretive paradigm. The acknowledgement that teacher's experiences shape their perceptions and usage of EWS address the point that knowledge is not objective, but our experiences and attitudes shape what we know, how we know it and therefore how we teach it (Pozzebon, 2004; Cohen, Manion & Morrison, 2007).

4.3 Case study research design

Research design is the plan or blueprint of how the research is to be conducted, and Babbie and Mouton (2007) identifies three types of qualitative research designs namely ethnography, case

studies and life histories. Ethnographic and life histories were not suitable for this study because ethnographic studies focus on larger entities or units of analysis (such as communities, social settings, and cultural groups) and life histories study life development of one or more individuals (Babbie & Mouton, 2007). Case studies are interested with a more clearly delineated entity (such as specific household, institution, or context) providing an in-depth investigation of the context (Babbie & Mouton, 2007; Yin, 2013), hence findings from this case study cannot be generalised to Grade 10 rural physical science teachers as a population. Yin (2013) view a case study as an empirical inquiry investigating a contemporary phenomenon in-depth within its real world context, and the current study was conducted in the natural environment of teacher's classroom teaching. "A case is a particular social situation chosen by the researcher in which some phenomenon will be described by participants' perceptions" (McMillan & Schumacher, 2006, p.62), and the teaching of science language represent a social situation and EWS is the explored phenomenon. Opie (2004) and Njie and Asimiran (2014) posit that a case study is a qualitative research where in-depth data is gathered about an individual, program, or event, for the purpose of learning more about an unknown or poorly understood situation, as mentioned in chapters 1 and 2, there is no existing research with rural physical science teachers to understand their perceptions and use of EWS while teaching. The case studied in this research study was a physical science teacher teaching in rural Acornhoek, Mpumalanga Province, and all four cases were then further studied collectively, while Acornhoek was the context of the cases.

Collective case study is when a number of cases are jointly studied to investigate a phenomena, institution, person, population or entity to understand a particular situation in-depth (Njie & Asimiran, 2014). Collective case study is when a case (physical science teacher) is studied in-depth to unearth something beyond the case itself (teachers' language practices) (Stake, 1995). Accordingly, this study provides a detailed understanding of a teacher's usage of EWS and the influence of their personal experiences (context) to how they perceive and address everyday words in science context during teaching. As such, each of the four participant teachers was a case studied in-depth individually and then collectively since they were from one research site, rural Acornhoek, which make this study a collective case study. My collective case study included four Grade 10 physical science teachers teaching in four secondary schools in rural Acornhoek, Mpumalanga Province.

4.4 Research approach

There are three main types of research approaches usually employed in educational research: qualitative, quantitative and mixed method research approaches (McMillan, 2012; Creswell, 2012). Qualitative research is characterized by understanding aspect of social life, and its methods which produce words rather than numbers as data for analysis, while quantitative research approach aims to give a measure of something (Patton & Cochran, 2002; McMillan, 2012). Mixed method research approach is associated with collecting and analysing data by combining qualitative and quantitative research approaches in one study (McMillan, 2012; Creswell, 2012). Both quantitative and mixed method approach were not appropriate for this study because the purpose was not to measure anything but to understand teacher's lived experiences with science teaching and learning, and their language practices during physical science teaching. Thus, the study used qualitative research approach for in-depth exploration of a situation or process in order to gain insightful understanding of that situation (Creswell, 2012).

Moreover, qualitative approach serves the purpose of describing and interpreting social actions (Njie & Asimiran, 2014) in a natural setting, which links with the purpose of this study to describe and critically interpret teachers' use of EWS in order to get in depth knowledge of rural teachers' perceptions and pedagogic approaches to STL including EWS. The importance of natural setting means qualitative researchers study things to make sense of, or interpret phenomena, in terms of the meanings people bring to them (Freebody, 2003; Denzin & Lincoln, 2004). Similarly, this study was conducted in 'natural' physical science classroom settings to better understand a situation and a process of teaching in science classroom using observation method. So qualitative approach was used to reconstruct and understand the reasons teachers used certain approaches to science teachers' language, and the factors that influenced their decision-making and their understanding of EWS or lack thereof.

4.5 Research data collection methods

Research methods are data collection techniques that are used by researchers to generate information about the specific subject under study, and can include observations, interviews, questionnaires, and document analysis (Babbie & Mouton, 2007; McMillan, 2012). Given the qualitative nature of this study, non-participant classroom observations followed by semi-

structured individual interviews were used to engage with the research questions and aims of this study.

4.5.1 Classroom Observation

Observation is the process of gathering open-ended, immediate information by observing people and places at a research site (Creswell, 2012), and is categorized into three types: structured, semi-structured, and unstructured observation. Structured observation knows in advance what to look for and has its observation themes worked out in advance, and was not suitable for this study (Cohen, Manion & Morrison, 2011). While, semi-structured observations have an agenda of issues but gathers data to illuminate these issues in a far less predetermined or systematic manner and this observation was suitable and used in this study (Cohen, Manion & Morrison, 2011). On the other hand, unstructured observation is far less clear on what the observer is looking for and therefore the observer has to go into a situation and observe what is taking place before deciding on its significance for the research and was not suitable for this study (Cohen, Manion & Morrison, 2011). For the purpose of this study, a non-participant observation was used where video recordings happened without becoming involved in the activities of the classroom, unlike in participant observation, where the observer takes part in the activities that they intend to observe (Creswell, 2012). This study used semi-structured non-participant classroom observation because "the observation of behavior as it occurs yields first hand data without the contamination that may arise from tests, inventories, or other self-report instruments" (McMillan, 2012, p. 163).

Thus non-participant observations usually involve the researcher seating silently in the classroom, capturing and/or taking notes as the teaching process progresses (Cohen, Manion & Morrison, 2007). I also stood at the back of the classroom with the video recorder recording silently the teaching practice focusing on the teacher's movements, talk, explanations and interactions with the learners, although learners' faces were blurred in the video. Additionally, observations have both advantages and disadvantages and the opportunity to record information as it occurs in a setting, study actual teacher's behaviour, and study an individual's difficulty with verbalizing their ideas (Creswell, 2012). Nevertheless, the researcher's presence might have led to some teachers not being vocal because of the stranger (researcher) in their classroom (Creswell, 2012), representing one of the disadvantages because it can negatively influence

teacher-learner interactions This study however had participant teachers and their non-participant learners behaving normally during classroom observations. In this method of data collection, I observed what EWS were used by physical science teachers and whether they explicitly, implicitly explained or there was no explanation of EWS given.

The video recording helped capture the word-to-word of what science teachers said in class, and how they said it (immediate reactions). The reason for this was to understand what wording was ~~is~~ used in science class, how it was used, hence the importance of understanding teachers' word-to-word in teachers talk. Moreover, video recording was necessary for this study because it captured how the teacher's conceptions of science teacher's language might play themselves out during teaching and learning. The strategy of video recording assisted with partialness of the observer's view and overcoming the tendency towards recording only the frequently occurring events, since observations tends be selective and objective in nature. If I did not use a video recorder for classroom observation, I might have missed important practices and participation, because of the various activities that were taking place in the classrooms. Thus, video recording enabled viewing and re-viewing of the various practices, interactions, and participation in the classrooms, as part of the analysis process and understanding the different interactions and practices during teaching and learning. The video recorder was always positioned towards the teacher and the recorded lessons differed in lengths, with the recorded lesson of 30 minutes minimum and the maximum of 60 minutes from all recorded lessons. In all the lessons, the video recorder was switched on from the beginning of the lesson until the last second of each lesson. Recording all sections of the lessons was done in order to capture both teacher talk and teacher approaches to EWS (including non-verbal communication). In total there were ten (10) observed lessons and Table 4.1 outlines the observed lessons per teacher and also provides each lesson's duration.

It was not possible to observe all teachers teaching similar topics because data collection was done in two sessions and all observed teachers were teaching different topics, Thabo was teaching physics while the other three participants were teaching chemistry sections of physical science, although they were all following the same syllabus

Table 4.1 Summary of the observed lessons (Appendix 4 for a sample of an observed lesson)

Teacher	Lesson Theme	Lesson Topic	Number of Observations
Ayanda	Matter and materials	Atoms and compounds	2 x 45mins 1 x 55mins 3 Lessons
	Chemical change	Physical and chemical change	
Thandi	Matter and Materials	Atoms and compounds	2 x 45mins 1 x 60mins 3 Lessons
Thabo	Electricity and Magnetism	Magnetic field of permanent magnets	1 x 45mins 1 x 30mins 2 Lessons
	Waves, Sound and Light	Electromagnetic radiation: Nature of electromagnetic radiation	
Simphiwe	Chemical change	Atomic mass and the mole concept (quantitatively)	1 x 55mins 1 x 60mins 2 Lessons
		The mole concept / theoretical and actual yield	

4.5.1.1 Process of observation: Observation Schedule

I adopted a similar observation structure from the previous research study conducted by Oyoo (2012) on the use of language in science classrooms. The following were the specific concerns during classroom observations and its design was influenced by the research questions and the objectives of the study:

- *What are EWS used by the teacher? Does the teacher explain (explicitly or implicitly) or provide the contextual meanings of these words or not? If so, then is there a clear approach in doing this?*
- *In sharing the contextual meanings of non-technical words used during teaching, does the teacher explore the other possible meanings of these words? Any other approaches used?*
- *Is there any approach to science teachers' language including EWS used by the teacher? If yes, what is the used approach?* Oyoo (2012, pp.861-862)

When observing the teacher's classroom interactions, special attention was made to the manner of word usage. Notice was made on teacher's attempts to differentiate or integrate the word meanings, especially for the EWS, teacher's explicit and implicit explanation of the contextual meanings of EWS, and also how teachers addressed the difficulties of science content that appeared to be originating from lack of word understanding.

4.5.2 Interviews

Interviews is one of the normal activities, however in research it requires a special skill to collect quality data in which questions are asked orally and subject's *(participant's)* responses are recorded, either verbatim or summarized (McMillan, 2012). There are three different types of interviews namely: structured, unstructured, and semi-structured interviews, and play different roles depending on the nature of the research. Structured interviews are mostly used in quantitative data collection because they are pre-prepared set of questions (usually in the form of a questionnaire) and these questions are asked in the same order in all participants giving participant's choices from which an answer is selected (Creswell, J. W., & Creswell, J. D., 2017) and it was not suitable for this study. Moreover, unstructured interviews are open-ended, broad, and difficult to conduct because it is highly subjective and it was not appropriate for this study (McMillan, 2012). On the other hand, semi-structured interviews does not have pre-determined, structured choices, rather it is open-ended yet specific in intent, allowing individual responses (McMillan, 2012). Semi-structured interviews are reasonably objective yet allowing for probing, follow-up, and clarification and it was the most suitable type of interview for this study.

This study used semi-structured individual face-to-face interviews to understand teachers' views on the role and importance of science teachers' language including EWS, and the teacher's reasoning of the choices made of observed teaching practices. Face-to-face interviews further allowed the observation of nonverbal responses and behaviours, which indicated a need for further questioning to clarify verbal answers. The semi-structured individual face-to-face interviews were chosen because they allow a close focus to specific issues of concern (use of EWS of STL), which lead to broader understanding of science teachers' perceptions on STL and factors shaping teachers' pedagogic approaches to STL including EWS. In so doing, I generated detailed information, since interviews allowed direct contact with the participants (Shneiderman & Plaisant, 2005), and they described in details their personal experiences of teaching physical science including EWS. Physical science teachers were interviewed individually to better understand observed practice and obtain insights into the usage of EWS (McMillan, 2012). During the interviews, all conversations were audio recorded and were later transcribed verbatim for analysis purposes. Audio recording the interview sessions allowed the researcher to pay attention to participants' responses and prompt for more information where necessary, compared

to taking notes while the participants would be talking. Moreover, the researcher chose audio recording because it can be destructive to write while a participant is talking and there is a possibility of not capturing everything the participant has said, resulting to missing important information (Cohen et al., 2007; Creswell, 2012). Therefore, audio recording provided the opportunity to listen attentively during interviews, and to later listen to the audio-recorded interviews and identify missing information or more needed information.

The data from classroom observations assisted in answering part of the research questions: "*What are Grade 10 rural physical science teachers' perceptions of using everyday words in science classrooms?*" and "*To what extents are rural physical science teacher's aware of the difficulties of everyday words when used while teaching science?*" Whereas collected data through interviews also helped in answering the research question: "*What are the factors that shape rural physical science teachers' perceptions and the usage of specific everyday words when used in science classroom context?*" and also answered partly the above two research questions. While this is the case, both collected data from classroom observation and teacher interviews were compared to find if teachers do what they think should be done in effectively teaching science.

The in-depth individual interviews were done after the last lesson observed from each participant. From all the interview sessions, the researcher had baseline questions asking teachers' views to science teaching, their approaches, experience, qualifications and other demographic issues but interviews were also guided by what transpired from observed classroom teaching. The total of four interviews was completed with all participants. Some teachers had more information to share with the researcher while other teachers had little to say but were all probed in case where unclear, short answers were given. The talking characters of teachers lead the interviews being different in terms of lengths agreeing with Irvine's (2011) point that there often a variation in the duration of interviews based because of some participants being outspoken than others. As such some interviews were 30 minutes long while some were about 50 minutes long, the shortest interview lasted for 33 minutes while the longest lasted for 53 minutes. All the interviews were audio recorded and then transcribed verbatim. In total, the four interviews took 2 hours, 52 minutes, 07 seconds. Table 4.2 shows time taken to complete each interview with each participant.

Table 4.2 Interview information with each participant (Appendix 3 for a sample of interview)

Participants	Time Taken	Where interviews happened
Ayanda	47 minutes, 34 seconds	Teacher's classroom after school hours
Thandi	53 minutes, 10 seconds	Teacher's office during school hours (break)
Thabo	38 minutes, 13 seconds	In the principal's office
Simphiwe	33 minutes, 10 seconds	Conveniently, in the teacher's car as the staffroom was full

4.5.2.1 Interview schedule

The interview schedule comprised of broad concepts for which I sought answers to. The interviews focussed on *teacher background knowledge, LOLT in shaping learners understanding of physical science concepts, teacher awareness of learners' language challenges with contextual social language of science*, and *teacher awareness of polysemous nature of commonly used English words in science classrooms*. Given the nature of semi-structured interviews, the phrasings of some questions were altered to suit each teacher's observed classroom practice. See Appendix 2 showing examples of sample questions that were asked during each teacher interview.

4.6 Context of the study

It important to understand the context in which this study was conducted so that background knowledge on why teachers would think or teach in particular ways are known. This study was conducted within four rural Acornhoek secondary schools, and used one Grade 10 teacher per school because each school had only Grade 10 physical teacher. All the schools were from the Green valley circuit in Acornhoek, which is located in Bushbuckridge, Mpumalanga province of South Africa. The languages spoken mostly in Acornhoek are Xitsonga, Sepedi and slight of Sepulana. It was difficult to classify Acornhoek as deep rural or semi-rural because two of the schools were closer to a newly built shopping centre and to some extent were exposed to various information centres including internet café for studying but the other two schools were far (approximately 15-20km) from the shopping centre. Of importance however, is that even the teachers teaching closer to the shopping centre acknowledged that theirs is the rural area. So from teachers' responses on the location of their school, it was clear that it is not easy to classify

Acornhoek. I thus concluded that some schools: Ithemba Secondary and Sunshine Secondary are located in deep rural while Zabalaza Secondary and Siyathuthuka Secondary are located in the semi-rural parts of Acornhoek area based on the availability of resources, high number of residents who work at the farms for life sustenance and infrastructural development which includes the newly built shopping centre and varying house structures with pit toilets while others with flushing toilets (big houses and small informal houses). Teachers from Ithemba and Sunshine schools, argued, during my informal conversations, that part of the Acornhoek where they are located is a deep rural area because of learners' poor general proficiency with English, learners having to walk long distances to and from school leading to high rate of late comers and prohibiting extra classes after school hours.

From the observation of the schools, I noticed that Ithemba and Siyathuthuka Secondary schools lack science teaching support materials including science laboratories and/or enough textbooks (four learners were sharing one textbook in Ithemba), lack of sanitation, and water. While there might be different conceptions of what Acornhoek is, from my informal observations of the Acornhoek area, to me Acornhoek is a large rural area or village located in Bushbuckridge. The village conception is influenced by the observation that chief and sub-chiefs still governs people of Acornhoek.

4.7 Research sampling

McMillan (2012) refers to research sample as a group of participants from whom research data is to be collected, and participants need to be strategically selected purposively, dimensionally or conveniently. The sample is defined as a smaller but representative collection of units from a population from which research data is collected to determine the truths about that population (McMillan, 2012). Echoing the same view, Johnson and Christensen (2008) assert that during sampling the researcher selects a portion of the population to represent the entire population under investigation. In qualitative studies participants can be selected purposefully, which means the researcher makes strategic choices concerning whom, where and how one's research will be done (Scott & Morrison, 2005; McMillan & Schumacher, 2010). Within purposive sampling, this study used criterion sampling strategy to select participating teachers, as it enabled the researcher to selects participants on the basis of identified characteristics (Grade 10 teacher, willing to participate) that will provide needed information, as such it ensures that participants have had

sufficient experience (at least 5 years of Grade 10 physical science teaching) with what is being studied (McMillan, 2012).

In this study, four schools[20] that offer physical science at FET level from those already involved in the bigger study (Appendix 5) from rural Acornhoek were selected. Within the selected schools, I worked with participants (teachers) of at least five years of physical science teaching experience. The secondary criterion was that participants needed to be teaching Grade 10 physical sciences. The third criterion was that participants were to have at least five years[21] of Grade 10 physical science teaching by the time of data collection. Therefore, one Grade 10 physical science teachers was selected per school and all selected teachers were English First Additional Language (EFAL) speakers.

4.7.1 Research participants

For data collection purposes, the researcher used criterion as a purposive sampling strategy to select four physical science teachers from the secondary schools that were involved in the larger research project from Wits School of Education that critically explores the conditions of teaching and learning that facilitate and/or constrain learning in rural high schools in Acornhoek, Mpumalanga province. The four schools worked with were selected on the basis of their involvement in the larger research project in which this study is located (to be explained in section 8.4.1). This made it easier to build a relationship with the school management team, the teachers as well as the learners since we have worked with them before. One of the school (Zabalaza Secondary), I have worked with them in 2014 to do my teaching experience as part of the larger research project's program. I had knowledge of the school and the other three schools;

[20] For purposes of identity protection of the four participant schools, pseudonyms were used when reporting the findings to ensure the anonymity of the participant schools. Thus, throughout this report the schools are referred to as Zabalaza Secondary school; Sunshine Secondary school; Ithemba Secondary school; and Siyathuthuka Secondary school, which are all pseudonyms referring to the participant schools.

[21] Maclellan and Soden (2003) define teachers with seven (7) years of experience as being knowledgeable experienced teachers who are in possession of an organized body of conceptual and procedural knowledge. While on the other hand, Rice (2010) views those teachers with five (5) years of experience as being effective in schools, unlike those with less than two years of experience (novice teachers). So, this study worked with teachers of at least 5 years of experience because of the assumption that they are experienced teachers with adequate content mastery relevant to the South African Grade 10 physical science curriculum and that they are effective teachers in their classrooms.

I had visited also in 2014 but never worked with them personally though I thought they were good schools to work with, hence selecting them for this study. The four schools are far apart, this was a disadvantage because on daily basis I could not schedule observations for all four schools but I would do a maximum of two schools only per day. The participants were chosen purposefully on the assumption that they possess knowledge on the subject matter, and that they can possibly provide insight on the teaching and challenges faced by physical science teachers with the language of school science. For purposes of anonymity and identity protection, in this study I used pseudonyms for all participant teachers, participant schools, and non-participatory participant learners.

4.7.1.1 Participating Schools

All four participating schools are referred to in this report as Zabalaza Secondary; Sunshine Secondary; Ithemba Secondary; and Siyathuthuka Secondary and are all situated in rural Acornhoek Village, Bushbuckridge in Mpumalanga province of South Africa. The four government public schools mirrors a shared understanding about the unbearable conditions of educational spaces (classrooms, science labs, libraries) and support educational spaces (kitchens, gardens, toilets). As such, these schools had some similarities and differences even though located in the same district, to address the complexity of rurality. Similarities in the schools were the learner population that comprised of only Black[22] South African learners coming from different socio-economic backgrounds. Across all four schools, they have overcrowded classrooms making it difficult for the teacher to move around the classroom, or to give each learner a special attention during teaching and learning processes. However, Thabo in Siyathuthuka secondary school mentioned informally that some of his learners do not attend regularly, which mean he does not usually have all learners in a lesson except during cycle tests and/or examination. Additionally, in all four schools, the language of learning and teaching (LOLT) was officially English language, but at times most of the observed teachers also use learner's home language especially for giving instructions during teaching.

The observed non-participant learners and all the participant teachers were second and/or third English language speakers, meaning that they all needed general proficiency in LOLT as the first

[22] Historically, Blacks includes Coloureds and Indians but in this section Blacks excludes the Indians and Coloureds

step in attaining contextual proficiency in STL including EWS. It is important to mention this issue of LOLT because it helped in understanding teacher language usage, as it was influenced greatly by learners' needs to be supported with LOLT so that the teacher could now guide learners move from the 'plain English' towards science contextual language. All four schools have National School Nutrition Programme[23] (NSNP) to provide food for the learners, which is cooked outside using firewood due to lack of electricity in the kitchens. (Images 1,1,2,3 of photographs 4.2, 4.3, 4.4, 4.5). Table 4.3 summarises the characteristics of the four participating schools.

Table 4.3 Tick table for participating schools

Characteristics / Schools	Zabalaza Secondary	Sunshine Secondary	Ithemba Secondary	Siyathuthuka Secondary
Located in semi-rural area	✓	×	×	✓
Located in deep-rural area	×	✓	✓	×
Approx. 5-10KM from shopping centre	✓	×	×	✓
Approx. 15-20KM from shopping centre	×	✓	✓	×
Availability of science laboratories / functioning	✓ / ×	× / ×	× / ×	× / ×
Enough science learners' textbooks	✓	✓	×	×
Availability of school library / functioning	✓ / ×	× / ×	× / ×	× / ×
Overcrowded classrooms	✓	✓	✓	✓
Practice of code-switching	✓	✓	✓	✓
Kitchens using firewood	✓	✓	✓	✓
Flushing toilets	×	×	×	×
Learner population-Black South African	✓	✓	✓	✓
Cultivated school garden	×	✓	×	×

[23] `National School Nutrition Programme (NSNP) is "A national programme managed by the Department of Basic Education, targeted at poor communities, whose objectives are to contribute to enhanced learning capacity through school feeding; promote and support the implementation of food production Initiatives in schools; and strengthen nutrition education for school communities" (DBE, 2018, p. 6).

Zabalaza Secondary School

Zabalaza Secondary school is Mathematics, Science and Technology Academy[24] (MSTA) based-school. The average numbers of grade 10 physical science learners in Zabalaza Secondary School were approximately 25. The school uses English language as the formal medium of instruction, even though in the observed lessons learners were mostly communicating with themselves and with the teacher through their home language (IsiPedi language). The 'core educational spaces' in Zabalaza Secondary School are appalling because of the unmanaged, dysfunctional, shelve less library (image 6 of photograph 4.1), dangerous Grade 10 classroom roof top (subsequent image 1), unmanaged science chemical storeroom (image 5), science laboratory which has been transformed into a learning and teaching classroom with new technology (including projector) from MST Academy (image 7) and also classrooms which are not used due to their dangerous conditions making it difficult for teaching and learning to take place (image 2 & 4). For the first two weeks I was in Zabalaza Secondary School, the new technology from MST Academy was used once to show demonstrations on Chemical Change and Physical Change topic. Even in these demonstrations, the teacher talk dominated the lesson while learners were sitting down quietly seeing the teacher performing 'magic' as some learners did not believe what the teacher was saying on these demonstrations. A practical example, when the teacher was demonstrating and emphasizing that through distillation process we can get back our salt and water separately, learners argued with the teacher saying that is impossible. This shows the unfamiliarity of learners with science procedures even though they have science apparatus for practical work but that is limited due to overcrowded classrooms hence the teacher end up doing demonstrations.

Three of the participating schools had no science equipment for practical work, had no effective or dysfunctional library making the teacher and his or her creativity to be the source of science information. Three of the four participating schools their Grade 10 physical science classes had no doors (for example see image 1 in photograph 4.1) and in most schools' windows had no glasses (see images 2, 1,1 of photographs 4.2, 4.4, 4.5). The lack of doors and glass windows

[24] Mathematics, Science and Technology Academy (MSTA) is the project aimed at improving the quality of maths, science and technology education through training of both teachers and learners and also encouraging more learners to study maths and science.

was of the advantage to teachers and learners since it was summer during my research data collection but seems to be a disadvantage in winter due to coldness. The four schools have pit toilets where both teachers and learners share no flashing toilets (images 2,3,3 of photographs 4.2, 4.3, 4.4) and the bush around Zabalaza toilet may pose threat to the safety of teachers and learners due to presence of for example snakes.



Photograph 4.1: Zabalaza Secondary School



Image 1: Zabalaza's Kitchen



Image 2: Zabalaza School's toilets

Photograph 4.2: Some educational support for Zabalaza Secondary School

What distinguishes Zabalaza Secondary School from the other three schools is that the other three schools had no science equipment for practical work, had no effective or dysfunctional library making the teacher and his or her creativity to be the source of science information. Three of the four participating schools their grade 10 physical science classes had no doors (for example see image 1 in photograph 4.1) and in most schools' windows had no glasses (see images 2,3,1,1 of photographs 4.2, 4.3, 4.4, 4.5 respectively). The lack of doors and glass windows was of the advantage to teachers and learners since it was summer during my research data collection but seems to be a disadvantage in winter due to coldness. The four schools have pit toilets where both teachers and learners share no flashing toilets (images 2,4,3 of photographs 4.2, 4.3, 4.4 respectively) and the bush around Zabalaza toilet may pose threat to the safety of teachers and learners due to presence of for example snakes.

Sunshine Secondary School

Sunshine Secondary School has approximately 36 average numbers of grade 10 physical science learners. The school uses English language as the formal medium of instruction, even though from the observed lessons, the teacher often referred to learners' home language (Sepulana language) but learners communicated with the teacher mostly through English language. Moreover, Sunshine's garden (image 2) seems to be taken care of and at the time of research data collection the other three schools had not functional food garden spaces.



Photograph 4.3: Sunshine Secondary School

Ithemba Secondary School

Ithemba Secondary school has approximately 30 average numbers of Grade 10 physical science learners. The school uses English language as the formal medium of instruction, even though in some instances of the observed lessons, the teacher used learners' home language to emphasize on questioning, to make analogies of the taught content and to give further instructions to the learners. Similarly, when learners were communicating with the teacher, they did so through their home language (IsiPedi language). The school had challenges with regards to physical science performances, even the school's principal also complained that physical science performance is deteriorating as there was only one learner of 30 Grade 10 physical science learners passed during the first school term examination (March 2017).



Image 1: Ithemba School's broken windows



Image 2: Ithemba's Kitchen



Image 3: Ithemba School's toilets

Photograph 4.4: Ithemba Secondary School

Siyathuthuka Secondary School

Siyathuthuka Secondary school has approximately 45 average numbers of Grade 10 physical science learners. The school uses English language as the formal medium of instruction and from the observed lessons; the use of learner home language was highly discouraged by the teacher. However, in some instances the teacher did use learners' home language to emphasize on questioning and to give further instructions learners. Similarly, when learners were communicating with the teacher, they used mostly English language with few individuals still communicating with the teacher through their home language (IsiPedi language).



Image 1: Siyathuthuka's broken windows



Image 2: Siyathuthuka School's roof top



Image 3: Siyathuthuka's Kitchen

Photograph 4.5: Siyathuthuka Secondary School

The above school's contexts shows the importance of rural context's consideration in understanding rural teachers' perceptions and usage of everyday words in science during their teaching of physical science because the above illustrated social realities shape participant teachers within their rural contexts. .

4.7.1.2 Participating Teachers

Three teachers who participated in this study were females and one male teacher and were all of African descent. Ayanda's[25] home language is Shona language, Thandi's home language is Sepedi (also mixed with Sepulana), Simphiwe's and Thabo's home language is also Sepedi. This study aimed at exploring how teachers in rural context use everyday words in science context during their teaching, whether they explain these words and whether teachers reflected any awareness of the difficulty of EWS experienced by the learners. Clear information about teacher's background is presented in Table 4.4 and only significant information such as teacher's citizenship or country of birth, gender, teaching experience, teacher qualification, subject specialization at university or college, teaching subjects, and school's administration responsibilities is presented.

[25] The names Ayanda, Thandi, Thabo and Simphiwe are not the real names of participant teachers but these are pseudonyms used in reporting the findings of this study to ensure anonymity and confidentiality of the participants.

Ayanda:

Ayanda was born in Zimbabwe and attended her lower and upper schooling including tertiary education (Bachelor of Science - *chemistry*) in Zimbabwe. She was taught physical science with the support of practical work in her public or government high school. She holds a view that physical science is not taught well in South Africa, including in rural Acornhoek because she said "*Most of the time it is taught theoretical*". When she came to South Africa, she registered with the University of South Africa (UNISA) to do her postgraduate certificate in education (PGCE) in 2012 majoring in physical science. Ayanda did her PGCE while she had already been teaching physical science.

Thandi:

Thandi was born in Mpumalanga province of South Africa and attended her lower and upper schooling in Mpumalanga, including her tertiary education where she trained in a local Mapulaneng College of Education for teaching in 1995 (majoring in physical science and maths). She then volunteered from 1997 to 2001 teaching physical science in different schools around Mpumalanga. Thandi then did advanced certificate in education (ACE) with the then Rand Afrikaans University (RAU) now known as University of Johannesburg (UJ). Currently, she is only teaching physical science in Grade 10 because of her other school management positions.

Thabo:

Thabo grew up in Tzaneen (Limpopo province of South Africa) and schooled in Limpopo. He then trained for physical science and mathematics teaching in Mapulaneng College of Education in 1991. He is currently teaching physical science in Grade 10 only and then mathematics and natural sciences in other grades.

Simphiwe:

Simphiwe schooled in Limpopo province and furthered her tertiary education with University of Limpopo, where she did Bachelor of Science (BSc) majoring in physics, geology, and mathematics. She then did her PGCE with UNISA in 2015 while she had already been teaching without teaching qualifications since 2013. Currently she is doing her BSc honours (part-time) with UNISA while teaching Grade 10 and 12 physical science and natural sciences full time. When doing her PGCE, Simphiwe specialized in physical science and mathematics teaching.

Generally, the participants had physical science teaching experience ranging from 5 years to 23 years. All the participant have arguably developed professional competence and are now more confident and unlikely to struggle with science content mastery and the usage of science language during teaching. The researcher was therefore confident during classroom observation and interviews that language practice would be evident in teaching if teachers foreground science language including EWS in their teaching.

In addition, 2010 TIMSS noted that about 47% of South African physical science learners were taught by teachers without teaching degrees. All the participants of this study have tertiary education and appeared to be qualified to teach physical science even though two participants trained at education teacher training colleges and the other two participants studied chemistry then postgraduate certificate in education. Of interest from the participants, none of them did a bachelor of education which questions rural teachers teaching approaches. Table 4.4 summarizes the population and sampling for this research.

Table 4.4 Summary of selected physical science teachers

Criteria	**Ayanda**	**Thandi**	**Thabo**	**Simphiwe**
Participating schools (*all rural government schools*)	Zabalaza Secondary	Sunshine Secondary	Ithemba Secondary	Siyathuthuka Secondary
Teacher's citizenship or country of birth	Zimbabwe	South Africa	South Africa	South Africa
Gender	Female	Female	Male	Female
Teaching experience	12 years	20 years	23 years	5 years
Teacher qualification	Chemistry / PGCE	Teaching diploma / ACE/ PG diploma in management	Teaching diploma	Bachelor of science (BSC) / PGCE
Subject specialization at university or college	Physical Science	Physical Science / Mathematics	Physical Science / Mathematics	Physical science / Mathematics
Teaching subjects	Physical Science / Mathematical Literacy	Physical science	Physical Science / Mathematics / Natural Science	Physical science / Natural Science
Admin responsibilities	Class teacher	Deputy principal / class teacher	Class teacher / SMT member	Class teacher
Learner grade	10	10	10	10
LOLT	English as EFAL	English as EFAL	English as EFAL	English as EFAL

Key* *PGCE=PostGraduate Certificate in Education; EFAL=English First Additional Language; ACE=Advanced Certificate in Education ; PG=Postgraduate; Admin=Administration; LOLT=Language of Learning and Teaching; SMT= School Management Team*

4.8 Actual data collection

4.8.1 Gaining access to research sites and consent of participants

This study is located within a larger research project as such I used the Mpumalanga Department of Education's permission of the larger research project in order to conduct the current study. The Mpumalanga Department of Education's acceptance letter (see Appendix 5) was used to gain access to the selected schools and permission was granted by both department and schools. I applied and obtained ethical clearance from the Human Research Ethics Committee of the Wits University on the 31st of July 2017 with the protocol number 2017ECE027M (see Appendix 10). When the ethical clearance from the Mpumalanga Department of Education and from Wits University was granted, I then approached the principals of the selected schools' with an additional letter requesting their further permission to work in their schools with their Grade 10 physical science teachers (see Appendix 6). I also explained the study in person to the principals and consented verbally to conduct the study in their school premises. The school principals then introduced me to the respective Grade 10 physical science teachers, with whom I discussed the purpose and ways of data collection for this study and then requested their voluntary participation through the teacher's consent form (Appendix 7). To be specific I requested teacher's consent that I observe and video record three of their physical science lessons on any physical science topic(s) they are teaching during the time frame of data collection. I also requested teachers that they participate in the interview after the observed lessons and the interviews were scheduled for after school hours. The physical science teachers consented.

Given that part of this data was to be collected through classroom observations, all participants gave me a maximum of 5 minutes during school break time to explain the study to the Grade 10 physical science learners and to ask for their permission to be observed (Appendix 9). Even though learners were not part of this study, but their learning space was used and as such needed their permission to video record their lessons, with the main focus on the teacher, learners assented individually. Given that most Grade 10 physical science learners are considered minors (less than 18 years), I also had to ask for consent from their parents (see Appendix 8) to video record the teacher's lessons with their learners in the classrooms and assented.

I affirmatively told both teachers and learners that the video recorded information would be used only for the purpose of this study, and not to be seen by any other person except my research supervisors and myself (researcher). As such, I assured both teachers and learners of confidentiality and anonymity of their identities and any information gathered during this study's data collection. During the explanation of their voluntary participation, I also mentioned to the teachers that if any of them decides halfway to withdraw his/her participation from this study they were free to do so without any negative effects on them. All the above were procedures taken to enhance cooperation from department of education, school (principals), physical science teachers and their learners with the researcher. Even though, Ayanda was initially no comfortable with the idea of video recording her while teaching, I assured her that her video recorded lessons will only be viewed by me (the researcher) and my supervisors only and that her name will not be mentioned or a picture of her teaching.

I collected data with all four teachers, even though there were breaks in between. The period of data collection was four (4) weeks (2 weeks for the first session and 2 weeks for the last session). During the first two weeks of data collection, I worked with three teachers (Ayanda, Thandi and Thabo) even though I only managed to observe one lesson of Thabo during the first 2 weeks. For the second 2 weeks of data collection, I then worked with Simphiwe and also finished observing and interviewing Thabo. The reason for the second 2 weeks of data collection was that Thabo was only available for one classroom observation and had to attend cluster meetings and moderations during the first 2 weeks. Moreover, Simphiwe was not available during the first 2 weeks of data collection due to other commitments; hence I went back to the field for the second 2 weeks to finalize data collection with all participants. So in total I worked with four teachers doing classroom observations and individual interviews with them all. All teachers participated willingly and from my first visit to their schools, they provided me with dates that suited them for me to visit their classrooms, the researcher then compiled all four teachers to make my own time table according to days and time for seeing participants.

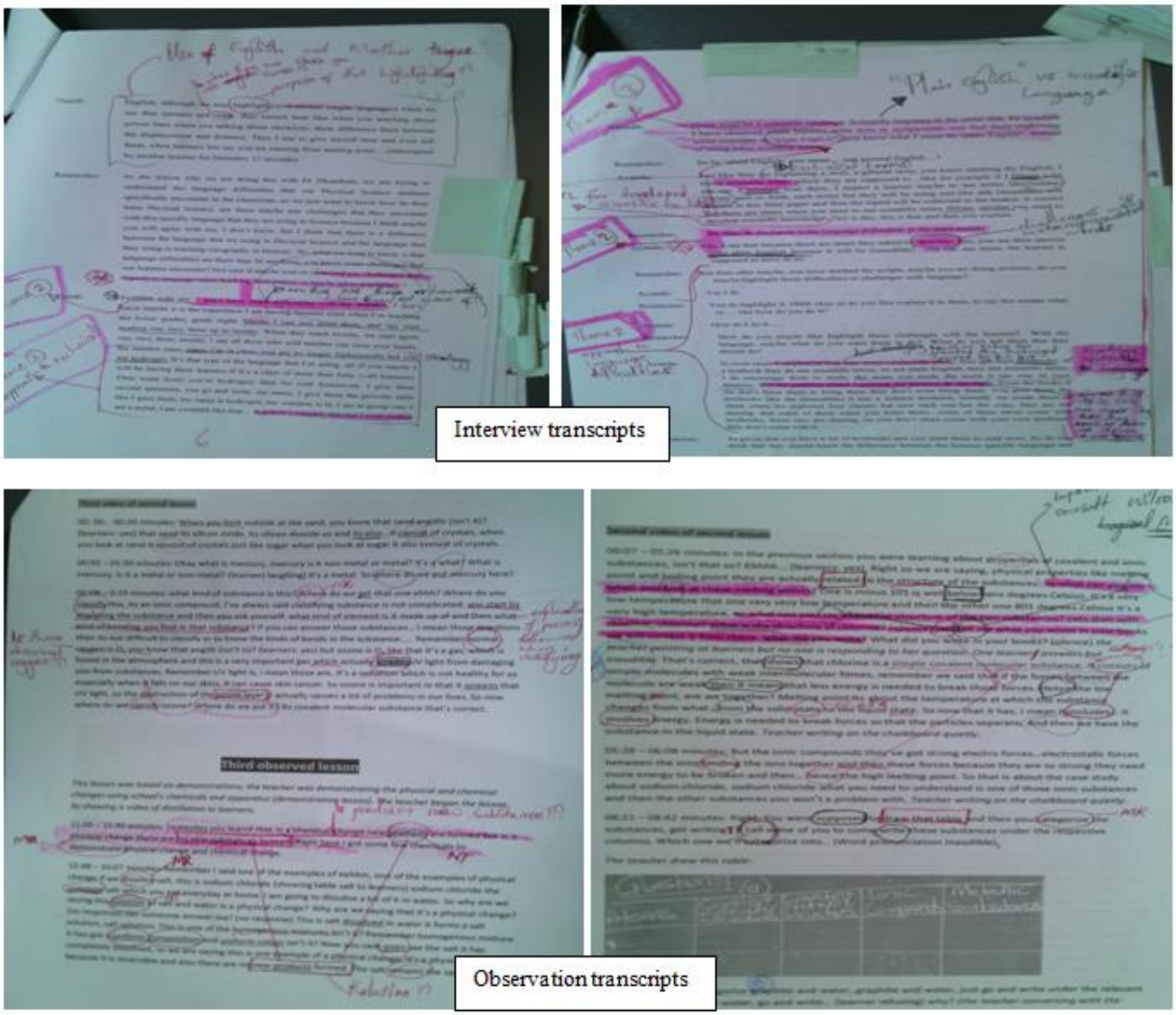
4.9 Data organization and process of analysis

Qualitative data organization and analysis is viewed as the search for general statements about relationships among themes of data and through the search process, data is ordered, structured, and also meanings are created. In qualitative studies, collection of data and its analysis are

usually intimate (Stake, 1995), which means I started analysing the research data during the data collection process. Immediately after each observed lesson, I watched the video recorded lessons repeatedly to identify certain everyday words that teachers have used during their observed lessons. To identify the EWS, I was guided by Oyoo's (2012; 2017) descriptions of everyday words in science context and also referred to Tao's (1994) and Cassels' and Johnstone's (1985) classification of non-technical words including EWS as discussed in chapter 2. After identifying all the EWS used in the overall observed lessons per teacher, I then asked about some of these words during the in-depth one-on-one interviews with teachers. Identifying the EWS from the observed lessons was not a linear process but an untidy process because I had to first identify, guided by Tao's (1994) and Oyoo's (2017) classification of non-technical words more specially the EWS. Some words were initially classified as being EWS and later classified as metarepresentational (which is not the focus of this study). To further organise, analyse and interpret the observed lessons and interview data, I used Creswell's (2009) idea of six steps of data organisation, Scott et al. (2011) pedagogical link-making (PLM) for the analysis and interpretation of classroom observation lessons, and qualitative content analysis (QCA) for the analysis and interpretation of interviews with teachers, which helped me identify patterns within each participant teacher and then across participant teachers. Even though, Creswell's (2009) six steps of data organization are rectilinear in nature, however in this study the process was not linear. Regarding Creswell's (2009) first step of data organization and preparation for analysis, I transcribed both classroom observation and interviews from each of the four teachers. In total, I transcribed ten (10) classroom observations in detail (see Appendix 4) and four (4) interviews verbatim (see Appendix 3). The summarized classroom observations were focused on various forms of teacher talk and EWS used by the teacher as emerged from the observations.

After transcription, the second step of data analysis involved reading through the data (Creswell, 2009) and I read through the transcribed classroom observation per teacher, making notes in the margins of the transcript. While reading through each teacher's classroom observation, I then read and reread the teacher's interview in line with the observed lessons, also making notes in the margins of the transcript. Following this process, I read all ten classroom observations parallel guided by the focus of the study, and then all four interviews parallel to highlight what was similar and what was different across teachers. I followed this procedure to have a general overview of the collected data and to also think about the best ways to organize the data, and

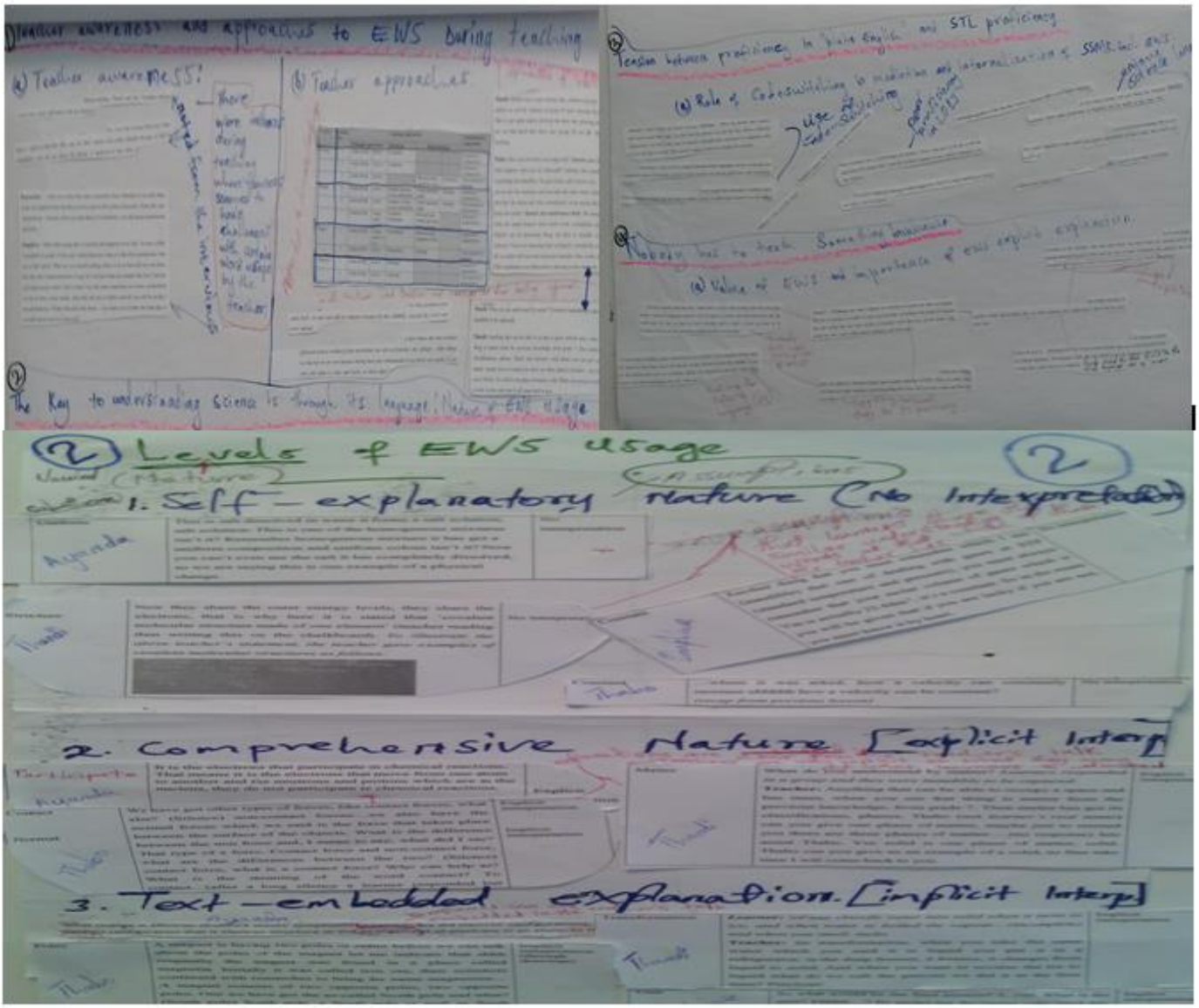
Creswell (2007) refers to this process as 'horizontalization'. Refer to photograph 4.6 and Appendices 11 and 12 showing the undertaken process of horizontalization of research data.



Photograph 4.6 Horizontalization of Interview and observation data

The third step was about organizing data by segmenting teacher's statements from the interviews in relation to their observed teaching practice (actual wording used during teaching). I then labelled the emerging patterns between teacher practice (observed lessons) and the assumed teacher practice (noted in the interview). Once the patterns were noted, I then coded these

patterns, grouping them in themes as the fourth step of data analysis (Creswell, 2009). Initial themes were identified and were further developed by re-engaging with the themes to refine them in relation to the focus and research question of the study. Refer to photograph 4.7 showing the selected part in data categorization and development for analysis.



Photograph 4.7 Process for the development of themes

According to Creswell (2009), the fifth step involves the advancement of themes descriptions for better representation of data in the discussion of the findings. In this step, I purposefully selected some parts from the data and pasted them on the chart under each theme (refer photograph 4.7

and Appendix 13), to describe and support the themes emerging from the data of this study. Pasting notes under each theme allowed me to identify the emergence and divergence of data within teachers and across teachers, in relation to reviewed literature and the theoretical framework for the study. See the following table 4.5 detailing the emerged themes.

Table 4.5 Categorization of data

THEMES	SUB-THEMES	THEME IDENTIFICATION *(examples from excerpts)*
Teachers' awareness and mediational approaches to everyday words used in physical science teaching	○ *Pedagogic approaches to LOLTS*[26].	○ *us who graduate from years back…we just read and try interpret because by then…you just do a trial and error method…* ○ *I don't know this new scientist [physical science teachers] from universities but with us from the…the colleges… other things we discover on our own because during those days Sphamandla if you finish your grade 12 you were just taken to class and teach…in those days.* See more excerpts in section 5.2 **Approaches in explaining EWS** ❖ *Helium, neon, argon and the likes, elements of group 18, why because they are called, we call the elements of group 18 inert, meaning they are rich, they are rich. They've got eight valence electrons but these ones (pointing at group 17 elements) they are not that much bad, these ones (group 18) are like 'Motsepe' they don't want anything.* ❖ *Have you ever been in an empty hall? (**learners: yes**) Some have been there neh, what happens when you say whoooahh!! (making some sound) in that room. (learners responding but inaudible). You get echoes, echo of your voice, the same will apply when you go into the mountain and you make the same sound, what will you hear? You will also hear the echoes neh. Now scientifically, we are saying what cause those things, what cause the echoes? (**learner: the sound bounce back**). The sound bounce back, good. And when the sound bounces back which*

[26] Explained in section 5.4

		words scientifically can we use? We have got English way of mentioning things but there is scientific way of mentioning things (silence). Voices are bouncing back in English, scientifically what can we say? We have the so-called reflection and refraction remember those words, those are scientific words. [This explanation was followed by a drawing to show these two words visually]
	○ *Teacher awareness of the difficulty posed by everyday words used in science context*	❖ *With me, I don't have much difficulties with my learners*. ❖ *Yes. I see that because there are times they're asked to describe this, you see their answer uses plain English because it will be (*inaudible*)…you can see more, the learner is supposed to have done so* ❖ *No, I don't think it, may be there*
The key to understanding a subject is to understand its language: Nature of EWS usage		**Non mediation of solution, uniform during teaching** • *This is salt dissolved in water it forms a salt solution, salt solution. This is one of the homogenous mixtures isn't it? Remember homogenous mixture it has got a uniform composition and uniform colour isn't it? Now you can't even see the salt it has completely dissolved, so we are saying this is one example of a physical.* **Implicit mediation of transformation during teaching** • *Its transformation, when you take the same water which you said it is liquid you put it in a refrigerator, in the deep freezer, it freezes, it changes from liquid to solid. And when you want to reverse the ice to liquid what do we call the process we did it in the first term? Precious!* **Explicit mediation of contact during teaching** • *We have got other types of forces, like contact forces, what else? (Silence) non-contact forces…we also have the normal forces which we said is the force that takes place between the surface of the objects. What is the difference between the non force and, I mean to say, what did I say? That type of a force. Contact force and non-contact force, what are the differences between the two? (Silence) contact force, what is a contact force? Who can help us? What is the meaning of the word contact? To contact…(after a long silence a learner responded but inaudible to be captured) To touch something hhhe yes you are right to touch something. If you touch something*

		you are in contact with that particular thing. **EWS's explanation or lack thereof and its implications to SSMK (interview data)** ❖ *Not necessarily, but when we talk about reactions with my learners maybe taking one element reacting it with another, it will give us or yield a certain product but we have others which cannot yield any, when Sphamandla I can't even give you the correct answer, but what I normally use is that when I react elements of this group, then that one they will give me this. That particular product, maybe from there you balance but maybe sharing it with learners, so that I can come to an understanding…* ❖ *"I was indicating that sound can pass through air, it moves through air, air becomes a media. Isn't waves can sometimes pass through water then water becomes a media".* ❖ *Preparing like making the solution, yah some of them will not understand when we talk about preparation or preparing but then the part of the solution, when we did concentration I specifically said that we are talking about concentration of solutions …when we talk about a solution we talk about <u>when a solute dissolves in a solvent</u> that is a solution…so you see the solution part won't be a problem. Maybe the preparation part but I don't think, maybe ayyh (mixed emotions) some will some won't [understand].*
Tension between general proficiency in "*plain English*[27]" and contextual proficiency in LOLTS (STL)	○ *The role of code switching in the mediation and internalization of science subject matter knowledge (SSMK) including*	○ *science language differs with English language* ○ *…greater percentage of science words are just science words* ○ *their [learners] English is very bad. It is very bad* ○ *You need to emphasise* [through mother tongue] *but I think 95 coma something per cent of our talk, it will be English.* ○ *Mhhhhh! I …do most of the work in English. Although there and there we emphasise when we see that they are stuck. Then mother tongue so that you simplify the concepts.* ○ *…using their [learners] home language it does not help*

[27] 'Explained in section 5.4

	EWS'.	*much* ○ *if you doing science you are doing the language [Science language which needs proficiency in English] and the maths at the same time*
Nobody has to teach something invaluable	○ T*he value of everyday words in science and the importance of explicit explanation while teaching science*'	• *I'm thinking it* [value] *is there because…* • *Ehheh they should know the difference* [between science and everyday meanings of EWS]. *When you study, even still when you study, somehow you develop along those lines, but if you don't study, and then you can't know* • *Myself I… [Thinking] but when I explain it to learners of course you don't get deeper. Why are we saying it's a noble, it's just a special name…* • *…nobody has to teach something that is not valuable* • *…I don't think, maybe ayyh [mixed emotions] some will, some won't* • *It is important. Ehhhm maybe I will do, I will explain to them tomorrow again when I do the corrections* • *… I did not actually think that they cannot know…*

The last step according to Creswell (2009) includes the creation of meanings to the raw data. For this study, I also noted that raw data was meaningless until it was made to talk to the focus of the study through interpretations. The meaning making process took into consideration the Vygotsky's (1978) concept of mediation, Scott et al.'s (2011) pedagogical link-making and Mortimer and Scott's (2003) social language of science, and other existing research studies conducted in science education with the focus on the science teachers' language. To analyse and interpret the data, I used pedagogical link-making and qualitative content analysis in relation to the chosen conceptual framework. Collaborating conceptual framework and analytical tools (PLM and QCA) allowed me to establish effective contexts in which the knowledge of QCA extracted the written, visual and spoken texts in the actual context of the participants.

4.10 Data analysis

The analytical framework for analyzing interviews and classroom observation was drawn from qualitative content analysis (QCA) in relation to pedagogical link-making discussed in chapter 3,

and helped the study to understand teacher's awareness of EWS, perceptions of teaching with and teaching through EWS, and also other factors influencing teacher's teaching approaches to science.

4.10.1 Analysis in terms of link-making and the communicative approach

Communicative approaches provide a perspective on how the teacher works with learners to develop science contextual ideas of EWS in the classroom (Scott et al., 2011). I have categorized classroom teacher's talk and interaction with learners during physical science teaching as being in the spectrum from dialogic to authoritative interactions, and from interactive to non-interactive interactions. This aspect of the framework is about whether or not the teacher interacts with learners and whether the teacher takes account of learner's ideas during teaching (Mortimer & Scott, 2003).

In some sections of the observed teacher's lessons, there were instances where interactions with learners were maintained greatly but with little attention to learners' ideas (Mortimer & Scott, 2003). This teachers' approach to the use of science teachers' language when communicating with learners proved to be interactive but also authoritative (interaction / authoritative communicative approach). On a different view from the observed interactive yet authoritative interactions, the teacher here listens to, and takes account of, the learners' points of view, even though these might have been quite different from the scientific view (Aguiar, Mortimer & Scott, 2010; Scott et al., 2011). The "…interactive teaching, dialogic interactions often occur when the teacher tries to elicit students' views" (Mortimer & Scott, 2003, p. 36). Scott, Mortimer and Aguiar (2006) describe non-interactive / dialogic communicative approach as to be self-contradictory when looked at surface value. However, non-interactive approach excludes participation of other people but with dialogic approach, attention is paid to more than one point of view (more than one voice is heard), and then non-interactive / dialogic approach addresses the teacher making statements to learners, at the same time not calling for any turn-taking interaction with learners (Mortimer & Scott, 2003; Aguiar, Mortimer & Scott, 2010). Lastly, non-interactive / authoritative communicative approach is like the formal lecture, where the teacher talking expansively, referring to his or her notes and writing copiously on the board without engaging with learners (Mortimer & Scott, 2003).

4.10.2 Qualitative Content Analysis

In addition to the classroom interaction analysis that focused on what the teacher was saying in class with specific emphasis on the EWS through pedagogical link-making analysis, I used qualitative content analysis (QCA) for analyzing interview responses. Mayring (2014) states that the central idea of QCA is to conceptualize the process of assigning themes to text passages as a qualitative-interpretive act, and language is viewed as a communication with attention to the content or contextual meaning of the text (Lindkvist, 1981; Tesch, 1990; Hsieh & Shannon, 2005). The actual analysis is defined as a systematic procedure of assigning themes to portions of text (Mayring, 2014), and interpretive in nature. QCA as a method of analysis argues that: "Words are the basic elements of texts and have a lexical meaning, including different meanings in respect to their text context ("blue" as a colour or a mood)" (Mayring, 2014, p.32). This means that there is a coexistence of many possible meanings for a word, which necessitates that each word be understood in the context of its usage. This further means that classroom teacher talk, specifically the used EWS, have science contextual meanings and therefore need contextual analysis in order to understand the science knowledge embedded in these words. Thus, QCA was used to critically interpret the content of interview text and classroom teacher talk through the systematic classification process of coding and identifying themes or patterns (Hsieh & Shannon, 2005), to critically engage and interrogate the taken for granted science teachers' language usage in science lessons.

Moreover, Mayring (2014) differentiates between two models of context, the micro context being the specific situation (time, location, the speaking (writing) person, his or her identity, aims, personal knowledge and his actions and plans), and the macro context being the allocation in society, the relevant reference groups and group actions and goals, the institutional and cultural background. These contexts helped provide the frame of reference for science teachers because their perceptions of and pedagogic approaches to EWS should be understood as relating to a particular context of communication (Mayring, 2014). The discussed contexts are vital for this study because every text is situated and therefore needs a context analysis in order to be understood well (Van Dijk, 2007; Mayring, 2014). Within QCA, I used four main stages of analysis (Figure 4.1): the decontextualization, the recontextualization, the categorization, and the

compilation to analyze the interview data (Bengtsson, 2016; Zhang & Wildemuth, 2016), and for the trustworthiness of the analysis, each stage was repeated at least twice.

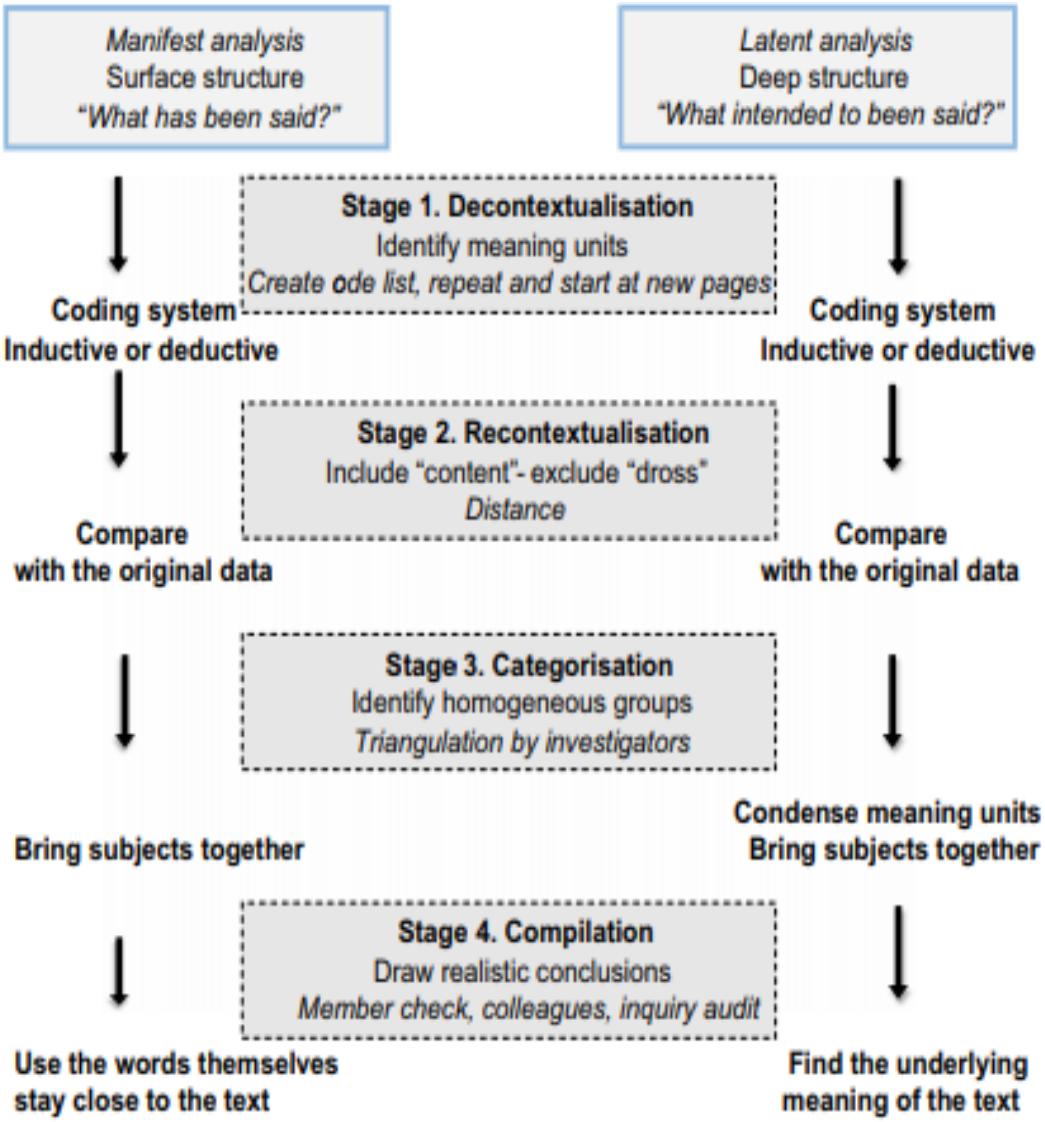


Figure 4.1 Process of interview data analysis through QCA (Adopted from Bengtsson, 2016, p. 9).

With the decontextualization stage, I first read through each transcribed interview text to learn "what is going on?" (Bengtsson, 2016, p. 11), and then read all interview texts across to make meaning of constellation of words, sentences or paragraphs relating to each other and answering the research questions of this study (Graneheim & Lundman, 2004). I then identified key words or phrases to sort it into patterns (Catanzaro, 1988), and initial meanings of whether or not

teachers are aware of EWS in their classrooms, whether or not they think it is important explain EWS, and of what other factors influences their teaching approaches to physical science were assigned. During the second stage, recontextualization, I then cross-checked if all aspects of the content were covered from interview data in relation to the aim of the study (Bengtsson, 2016) and some data "dross" was not included in the analysis because it was not helping to answer any of the research questions of this study.

After recontextualizing the interview data, I then categorized it. To now extract sense of the data, I divided the themes on the basis of the research questions and then on basis of the aims of the study (Bengtsson, 2016). In the last stage, the compilation, I then compiled all established themes and was interpreted according to the micro and macro contexts of the teachers (Mayring, 2014).

4.11 Chapter summary

The paradigm informing my research design and research approach has been reviewed. This chapter discussed in details the research process and methods to be used in generating data, organizing data and then analysing the qualitative data. The chosen qualitative ways of data gathering was to capture: **(1)** Physical science teachers' perceptions of and approaches to everyday words used in science during their teaching, **(2)** The extent to which physical science teachers are aware of the difficulty and influence of everyday words used in science context on learners' learning of science, **(3)** Factors that shape rural physical science teachers' perceptions and use of particular everyday words used in science. These qualitative ways were non-participant classroom observations and then semi-structured, in-depth teacher interviews. The current study's research questions and purpose were addressed effectively through data from classroom observations and teacher interviews. Choices made for the research processes and methods have been scrutinized and justified and then ethical considerations were also outlined during the description of data collection processes. The following chapter (Chapter 5) presents and discuss the findings from the collected qualitative data.

CHAPTER 5

TEACHERS' PERCEPTIONS AND USAGE OF EVERYDAY WORDS IN PHYSICAL SCIENCE TEACHING: PRESENTATION OF FINDINGS AND DISCUSSION

5.1 Introduction

This study therefore sought to understand rural Acornhoek Grade 10 physical science teachers' perceptions and usage of everyday words when used in science classrooms, it specifically focuses on whether teachers are aware of the difficulty posed by EWS, and to also interrogate the role of rural context in understanding and using EWS. In this chapter, I critically analyse teachers' interviews and observed teachers' different science lessons, and the data is analysed against the background of the reviewed literature and the theoretical frame. The analysed data was to answer the following research questions:

a) What are Grade 10 rural physical science teachers' perceptions of using everyday words in science classrooms?

b) To what extents are rural physical science teacher's aware of the difficulties of everyday words when used while teaching science?

c) What are the factors that shape rural physical science teachers' perceptions and the usage of specific everyday words when used in science classroom context?

This chapter organized and discusses the findings according to four identified themes and sub-themes (as discussed in section 4.9). All four themes are discussed accordingly in this chapter. The first theme is **"Teachers' mediational approaches to and awareness of everyday words used in physical science teaching"** address teachers' awareness of the possible difficulties instigated by EWS including approaches to physical science teaching using EWS. The findings from both the observed classroom lessons and the interviews suggests that some physical science teachers were aware of the language issues in their classrooms while others were not, and teacher awareness is influenced by various factors at play. Within this theme, two sub-themes were identified, '*Teacher awareness of the difficulty posed by everyday words in science'* and

'Pedagogic approaches to LOLTS[28]*'*. The first sub-theme details evidence of teacher awareness of difficulties with using everyday words in science and the second sub-theme looks critically at the teacher approaches, or lack thereof, in dealing with language issues in science, especially the use of everyday words in physical science classrooms. The second identified theme is "**The key to understanding a subject is to understand its language: The nature of everyday words used during science lessons".** This theme presents everyday words that teachers used in science classroom while teaching physical science lessons.

In addition, the third identified theme **"Tension between general proficiency in "*plain English*[29]" and contextual proficiency[30] in LOLTS (STL)"** addresses teacher's knowledge of learners' proficiency in English and teacher's understanding of the contribution of general English to comprehension of science content. Under this theme from the interviews and observed classroom lessons, a sub-theme was identified, '*The role of code switching in the mediation of science subject matter knowledge (SSMK) including EWS'*. The last theme **"Nobody has to teach something invaluable"** addresses teacher's perceptions of everyday words use in science lessons. A sub-theme '*the* v*alue of everyday words in science and the importance of explicit explanation while teaching science*' was illuminated from the above theme. This sub-theme looks at teacher's value of and importance of explicitly explaining or making explicit references to everyday words in science. Following is the discussion of each theme as emerged from the observed classroom lessons and in-depth individual interviews or from both interviews and classroom observation.

[28] LOLTS in the context of this study refers to the science contextual language used in learning and teaching physical science, including EWS.

[29] 'Plain English' is a phrase said by one of the participant teachers to refer to the use of general English without scientific terms in a science text. In this study 'plain English' refers to the use of English language without being contextualized to science text, just general English without science discourse.

[30] By contextual proficiency I mean the need for both teachers and learners to "…understand the meanings of everyday words in the context of use during the science *(teaching and)* learning process" (Oyoo & Semeon, 2015, 44). [Italics added]

5.2 Teachers' mediational approaches to and awareness of everyday words used in physical science teaching

This theme is about teachers' approaches to mediating physical science knowledge including EWS and thereafter teachers' awareness of the possible difficulties prompted by EWS. The two sub-themes that emerged from this theme are *'Teachers' pedagogical approaches to everyday words used in physical science lessons* and '*Teacher awareness of the difficulty posed by everyday words used in science context'*. Preceding research studies have mentioned that more often physical science teachers are not aware of the difficulty posed by everyday words used in science to the learners (Oyoo, 2012; 2017; Ncube, 2016). It is concerning that everyday words used in science classrooms have been widely noted to present problems in learners' learning of science, yet science teachers' pedagogic approaches to everyday words use in science classroom teaching remains unmapped in literature.

5.2.1 Teaching approach to everyday words used in physical science lessons

The sub-theme emerged from the teacher's observed lessons of everyday words used in the science classroom context and the nature of mediation, including teacher's interview responses on their approaches to EWS in science lessons. As mentioned in chapter 4 that teachers were not restricted to a particular topic for this study, considering the physics and chemistry strands in physical science, instead participants were observed within their natural settings. Different teaching approaches were observed in different physical science lessons, which varied from lecture method; dialogic; interactive; teaching pace; authoritarian; language choice. These approaches shaped the presentation of everyday words used in physical science lessons as teachers dominantly explained the words implicitly, while in few instances some teachers explained EWS explicitly (this was at its minimal level), which could influence learner's epistemological access. For example, when Ayanda taught about Atoms and Compounds during her second lesson, the teacher stood in front of the class referring to her textbooks and focused specifically on presenting science content without paying attention to the nature of words used. The nature of lecturing emphasise the representation of facts or important information from the content (Mortimer & Scott, 2003) and it influences the choice of language and words being used by the teacher. In addition, the pace of a teacher could potentially contribute to learners' difficulty with understanding the meaning of EWS in science context, especially fast pacing as

was observed from Ayanda and Simphiwe's lessons. The fast pacing influences the nature of mediating science content and concepts because a teacher might take for granted the need to explain the meanings of specific everyday words use in the science classroom context, which could result to learner's mistaking them with other words that sound alike. This was observed when Ayanda explained about sodium atom forming sodium ion,

> ***Teacher:*** *Remember that first term you learnt that metal atoms react by losing the valence electrons, the few electrons in the outer most shell, which we call the valence electrons. So sodium atom has got one valence electron, so it reacts by losing the single valence electron. You also learnt that the non-metals, they react by accepting electrons.(*teacher talking fast*)*
>
> ***Teacher:*** *Right! So when sodium loses that single valence electron, then it means that the new electron structure, electron configuration, is this one (*point at this structure: $1S^2\ 2S^2\ 2p^6$ on chalkboard*), you understand. That is how you were supposed to show it that, that is the change that takes place when a sodium atom forms an ion. Right! And then that was D1, D2 says (*reading from the textbook*) what change if any occurs in the nucleus when the ion is formed? When the ion is formed (*emphasis as she goes to write on the chalkboard and before writing she turns and ask a question) *do we have any changes in the nucleus of the atom?*
>
> ***Learners:*** *(*responding in a chorus*) No*
>
> ***Teacher:*** *The answer is no.*
>
> ***Teacher:*** *Remember when you learnt about reactions…I mean chemical bonding in the first term, we said it is only the electrons out of the three subatomic particles, its only the electrons that participate in chemical reactions but the protons and neutrons because they are in the nucleus they do not participate in the chemical reactions. Normal chemical reactions, they do not participate (*with emphasis*), so that is why we saying there is no change in the nucleus of the atom. So no change (*she writes 'no change' on the chalkboard*). [The underlined are EWS left without contextualization to science contextual meanings]*

Additionally, the lecturing and authoritarian teaching approaches are also linked with teacher – centred approach, as was also observed in Thandi's chalk and talk lessons and usage of textbook without allowing learners to raise any question, concerns, comments or have any contribution during lessons in all Grade 10 classes. Of interest with the consistency of teaching approach is the link with Thandi's interview response "*us who graduated from years back…we just read and try interpret because by then…you just do a trial and error method…*", which suggest the influence of the nature of training she experienced and questions the science content knowledge imparted on her as a science student and as a science teacher. Furthermore, if Thandi relies on and interpret the textbook, it can be presumed that everyday words that are used during the

lesson are overlooked and unexplained because most of the EWS are not explained in grade 10 physical science textbooks (Elferink, Kirstein, Maclachlan, Pillay, Rens, Roos, & White, 2012), and is unsurprising that her lessons were dominantly teacher centred and authoritarian considering the "trial and error teaching method." Although Thandi stated the above-mentioned teaching approach, she also used question and answer approach as a way of checking learners' prior knowledge of the topic and also include them in the learning process.

> ***Teacher:*** *Particles making a substance, this is not a new topic. Okay Sipho (*trying to get Sipho's attention*), this is not a new topic altogether it's from previous grades, Grade 9, Grade 8 up to Grade 7 where you were talking about matter. Can we remind ourselves,* ***what is matter****? Happy!* ***Matter definition*** *from Grade 8, Grade 9 or even Grade 7.*
>
> ***Learner:*** *Responding but inaudible.*
>
> ***Teacher:*** *Anything that occupies space and has mass. Do you want to tell me that this chalkbox, this box is matter, is an example of matter? (*showing the box of chalk*) (*learners say *yes).*
>
> ***Teacher:*** *Why? (*then the teacher quickly answered her question before waiting for learners*)*
>
> ***Teacher:*** *when I put on a scale it will have a certain reading. So you said matter is anything that occupies space and has mass. Zama (*not learner's real name*) can you* ***give us three phases of matter****... Zama!*
>
> ***Learner:*** *Metals, semi-metals and non-metals (*the teacher was saying these after the learner*)*
>
> ***Teacher:*** *Metals, semi-metals and non-metals, (*teacher looking at and repeating after the learner, showing that this was not the answer she expected*)* ***three phases of matter****, it's a try akere (isn't)… Phases of matter!! (*the teacher pointing at another learner*)*
>
> ***Learner:*** *Solid, gas…*
>
> ***Teacher:*** *Good! Solid, liquid and gas, three phases, we have got solid phase, gaseous phase, liquid. Zinhle! (*not learner's real name*) just choose from the three… and you give us two examples…*

While question and answer could be considered as a traditional way of teaching, it plays a particular role in a lesson depending on the teacher's pedagogical reasoning. In this case the teacher wanted to understand whether learners remembers previous knowledge to link with the current content to be taught, as Scott, Mortimer and Ametller (2011) state the importance of teachers and learners to make connections between ideas and concepts in the ongoing meaning-making interactions during teaching and learning of science. It is important to recognise that Thandi did not take it for granted that learners know about the concept to be learnt, but realised the significance of finding out from the learners what they remember to understand how much they still remember and from where to begin with the teaching of "matter". Thalheimer (2003)

argued that the use of questioning is effective and allows learners to retrieve information from the memory, give learners feedback about their misconceptions, focus learners' attention on the most important learning material, and repeat core concepts, giving learners a second chance to learn, relearn, or reinforce what they previously learned or tried to learn. Without overlooking this teaching approach, I noticed at the beginning that the teacher asked different questions, which could convince learners as the learner gave a different answer until a teacher emphasised the question for another to get the right answer. This can possibly be linked to the "trial and error method" she mentioned in relation to the training she received which is compared with the university training that is perceived as superior when compared to the college training, as the response illustrate:

> *...I don't know this new scientist [physical science teachers] from universities but with us from the colleges, other things we discover on our own because during those days Sphamandla if you finish your Grade 12 you were just taken to class and teach…*

The response suggest that the reality in rural schools is that some teachers were under trained and untrained, consequently discovered and learned the science content as they teach it, hence "trial and error teaching method". Gardiner (2008) posits that teacher training colleges trained teachers to use rigid, rote-learning methods in the classroom, promoting authoritarian teacher, while discouraging learner questioning or critical analysis. Thus, given the classroom observations, the nature of training, textbook knowledge reliance, and the purpose of the lesson, it was not surprising that the teacher mainly focused on teaching the technical words and overlooked the everyday words use her science lessons.

Moreover, more often teachers used rote-learning teaching approaches which seemed not to be effective, as it did not also allow them to explain the meanings of EWS due to the overlooked importance of EWS's explanation and functional value. This sub-theme also addresses what Scott et al. (2011) call 'differentiation' in the explanation of science ways of knowing from that of everyday knowing which should be done by teachers through their teaching approaches. Regarding the second sub-theme '*Teacher awareness of the difficulty posed by everyday words used in science context',* it indicates that teachers are oblivious of the functional value of the EWS which to some extent leads to their unawareness of the difficulties posed by EWS on learners. In addition, through this sub-theme it appeared that the contextual nature of EWS was one of the contributory factors into the difficulty of the EWS.

5.2.2 Teaching approaches to physical science including EWS

The sub-theme '*teaching approaches to physical science including EWS'* emerged primarily from the observed teachers' classroom practice, and also linked with teacher interview responses on their approaches to language issues including EWS. Based on the observation, classroom communication was dominated by teacher talk, as they control classroom talk by:

- Using lecture method of teaching, where the teacher stands in front of the class and then keeps on talking until he/she asks a question to the learners.
- Silencing learners not to raise any question or concerns and this was dictated by the fast teaching pace and the use of English as LOLT which learners seemed uncomfortable with.
- Deciding who should talk regardless of whether or not their hands are up during questioning time.
- Limiting group work and classroom discussion
- More interestingly using English language while in almost all observed classrooms learners had some queries and raise them in their mother tongue languages (mostly in IsiPedi language) and more often teachers did not respond to these queries.

The above modes of communication, for example fast teacher's teaching pace, as observed from some participants, could potentially contribute to the difficulty of the EWS as teachers might pronounce these words fast and be mistaken with other words that sounds alike. Teacher's fast teaching pace could possibly lead to some EWS that are phonetically similar being confused, because of unclear articulation in wording, for example, words such as reaction, solution, structure and others. This has implications in the understanding of science processes and it indicates the role played by teachers pedagogical approaches in the teacher talk including EWS (words being confused). It could also be said that the observed classroom communication reflects teacher's most preferred teaching approaches to physical science with regards to classroom talk, which utilizes mostly language including everyday words used in the science context.

Thandi

From the discussed topics that were taught, Thandi used a mixture of teacher-centered approach and question and answer approach depending on the learners' needs. In her first observed lesson,

she used chalk and talk strategy and towards the end of the lesson she used a periodic table poster to show placement of metals, semi-metals and non-metals in the periodic table space. The second observed lesson was a repetition of the first lesson to another Grade 10 class and used almost the same approaches as lesson one, the difference in lesson two is that the teacher referred more on the learners' textbook. On her third observed lesson, Thandi used chalk and talk with the help of visual representation: ball and stick model used towards the end of the lesson. This model could have been used effectively, as observed from the lesson the model was used as a demonstration of compounds, maybe the teacher could have given learners an opportunity to construct what they think is the model for compounds, diatomic elements and then from there the teacher to discuss with learners because she had enough material to give all approximately 48 learners. Dominantly Thandi used a 'teacher centered' approach, where there was limited classroom interactions between the teacher and learners but her lessons were located more towards the non-interactive/authoritative dimension, but with some interactive interventions by the teacher, due to her lecturing style practiced most of the times. The observed teacher centered approach in Thandi's classroom teaching was in agreement with what she alluded on during the interview, as she said "*us who graduate from years back…we just read and try interpret because by then…you just do a trial and error method…*" of teaching science especially through practical work. This response suggests that Thandi's 'teacher-centered' approach is influenced by her teacher training experiences from the teacher training college she trained at.

Moreover, Thandi also used question and answer teaching approach as can be seen for example from the following excerpt,

> ***Teacher:*** *Particles making a substance, this is not a new topic. Okay Sipho (trying to get Sipho's attention), this is not a new topic altogether it's from our first term work, first term, previous grades, Grade 9, Grade 8 up to Grade 7 where you were talking about matter. Can we remind ourselves, what is matter? Happy! Matter…definition from Grade 8, Grade 9 or even Grade 7. Happy!*
>
> ***Learner:*** *Responding but inaudible.*
>
> ***Teacher:*** *Anything that occupies space and has mass. Do you want to tell me that this chalkbox, this box is matter, is an example of matter? (showing the box of chalk) mhhhh…? (learners say yes).*
>
> ***Teacher:*** *Why?*
>
> ***Learners:*** *Responding all at once with different reasons (could not capture their clear responses)*

Teacher: *when I put on a scale it will have a certain reading. So you said matter is anything that occupies space and has mass. Zama (not learner's real name) can you give us three phases of matter... Zama!*

Learner: *Metals, semi-metals and non-metals (the teacher was saying these after the learner)*

Teacher: *Metals, semi-metals and non-metals, three phases of matter, it's a try akere (isn't)… Phases of matter!! (the teacher pointing at another learner)*

Learner: *Responds but in a low voice (could not be captured).*

Teacher: *Ahhhhh! Let me stand here so that I can hear you (teacher moving away from the learner who was responding). Three phases of matter!*

Learner: *Solid, gas…*

Teacher: *Good! Solid, liquid and gas, three phases, we have got solid phase, gaseous phase, liquid. Zinhle! (not a learner's real name) just choose from the three… and you give us two examples…*

In this teaching episode, the teacher is asking a series of questions and also probing learner's understanding of the concepts taught. Thalheimer (2003) argued that the use of questioning is effective and allows learners to retrieve information from the memory, give learners feedback about their misconceptions, focus learners' attention on the most important learning material, and repeat core concepts, giving learners a second chance to learn, relearn, or reinforce what they previously learned or tried to learn. However, Thandi's dominated approach could also lead to improved learning of science only if learners pay attention to the questions and attempt to answer them (Thalheimer, 2003), and this questions the level of learners' learning as they did not respond to most of teacher's questions.

Additionally, Thandi showed an interesting comparison of training then (pre-1994 teacher training colleges) and now (post-1994 teacher training universities), describing her teacher training as not having prepared her enough to effectively teach physical science. Thandi's teacher preparation experiences could positively and/or negatively influence her pedagogical approach to language practice including the use of EWS during her (their) planning and actual teaching of physical science. The following indicates preferred teacher's approach in the classroom due to her 'own' teaching experience (as a learner/teacher); teacher preparation (in college); and personal preference as a teacher. Thandi said:

…I don't know this new scientist [physical science teachers] from universities but with us from the…the colleges… other things we discover on our own because during those days Sphamandla if you finish your Grade 12 you were just taken to class and teach…in those days.

This point shows one factor (personal experiences and training) which might influence teachers' approaches. The teacher seem to suggest that she (they) didn't experience 'appropriate' training then (colleges) as compared to now (universities). The teacher experiences or background with poor science teacher training in colleges pre-1994 questions the teacher's teaching approaches to science content when initiating learners into science discourse. Moreover, Thandi's utterances makes it interesting to also briefly look into rural physical science teachers' training, probably to unearth contextual and situational influence into science teachers classroom teaching approaches. Thandi's utterances fits well when situated into the South African education context, as Gardiner (2008) argues that teacher training colleges trained teachers to use rigid, rote-learning methods in the classroom, promoting authoritarian teacher, while discouraging learner questioning or critical analysis.

Ayanda

In lesson 1 and 2, Ayanda used a mixture of teacher centered approach (chalk & talk) and learner-centered approach (practical work/demonstration and question & answer) through learner's textbook. The teacher taught the same topic (Matter & materials, and Atoms & compounds) for lesson 1 and 2 to two different Grade 10 classes. Lesson 3 was a different topic (Chemical Change) that was taught using simulations and practical demonstrations, even though some learners seemed not to have been engaged during the demonstrations possibly due to the large number of learners in Ayanda's classroom. All three observed lessons were dominated by teacher talk and question and answer approach to guide learners towards one perspective of viewing science ideas (scientific way of explaining). I noticed that Ayanda's question and answer approach resulted in her overseeing differentiating between scientific ways and everyday ways of understanding and explanation for both EWS and technical words including as shown in the following excerpt of lesson 1,

> ***Teacher:*** *G says chlorine melts at minus 101 degrees Celsius, sodium chloride melts at 801 degrees Celsius. What does this information tell you about the structure of each substance, the structure of each substance? (*Teacher reading the question from the textbook*). Right… in the previous section you were dealing with properties of ionic and covalent substances, properties of ionic and covalent substances. And we said that physical properties like melting point and boiling point they are actually determined by the bonds, the types of bonds in the substances, you remember that…? And we said the stronger the bond the higher…*
>
> ***Learners:*** *The melting point*

> ***Teacher:*** *It means that the stronger the bonds, the more energy needed to break the forces (*teacher giving the theoretical background of strong bonds which leads to higher melting points*), is that so? (teacher asking learners). (*No response and then the teacher wrote the answer on the chalkboard).
>
> ***Teacher:*** *Question one, you are given a list of substances there, these substances you must classify them under the subtopics which are given, classify them as atoms, covalent molecular structure, covalent network structure, ionic compounds, metallic,* ***it's supposed to be metallic substances*** *not metallic compounds there, actually it's a mistake. (*teacher saying there is a mistake in a physical science textbook*)*

It is everyday words used in science classroom context like 'structure', 'properties', 'classify', and 'network' that should have been explained to the learners so they may know the type of covalent structure but that is networked due to its forces which needs higher energy to be broken. The teacher did not attempt to make links between everyday and scientific ways of knowing and explaining the EWS and this is in contrast with Mortimer and Scott (2003), Oyoo (2012) and Scott et al. (2011) who suggest making links between everyday and scientific ways of knowing, especially everyday and science contextual meanings of EWS. Moreover, the teacher's approach represents Scott et al.s' (2011) non-interactive/authoritative communicative approach, because from the observed lessons the classroom talk was controlled by the teacher deciding when and how learners should talk and learners were not given the chance to be active during the lesson. According to Mortimer and Scott (2003) refers to non-interactive/authoritative approach as being when the teacher talks expansively, referring to his or her notes and writing copiously on the chalkboard, which is what Ayanda was doing in the above excerpt.

In lesson 3, Ayanda performed a demonstration of the concepts of chemical and physical change. As much as physical science curriculum (DBE, 2011) recommends simple practical demonstrations but it does not clearly prescribe the roles to be played by a teacher and the learner during these demonstrations. As such Ayanda did most of the demonstrations with learners sitting observing her chemical reactions. Of importance however was the dominance of teacher talk and less of learner engagements with demonstrated concepts. Learners were involved sometimes when they had to answer a question with a yes or no answer in most cases and at times when they were arguing with teacher regarding the products of a particular solution demonstrated. Nonetheless, the teacher often answered most of her questions because learners could not answer; see the following excerpt from lesson 3, for an example,

> ***Teacher:*** *Remember I said one of the examples of eehhm, one of the examples of physical change if we dissolve salt, this is sodium chloride (*showing table salt to learners*) sodium chloride the common salt which you eat everyday at home. I am going to dissolve a bit of it in water. So why are we saying this solution of salt and water is a physical change? Why are we saying that it's a physical change? (*no response*) can someone answer me! (*no response*) This is salt dissolved in water it forms a salt solution, salt solution. This is one of the homogenous mixtures isn't it? Remember homogenous mixture it has got a uniform composition and uniform colour isn't it? (*teacher answers herself*). Now you can't even see the salt it has completely dissolved, so we are saying this is one example of a physical change. It's a physical change because it is reversible and also there are no new products formed.*

In another teaching episode of lesson 2, the teacher said,

> ***Teacher****: Okay what is mercury, mercury is it non-metal or metal? It's a what? What is mercury, is it a metal or non-metal? (*Learners were not responding and the teacher is trying to guide learners but the problem she never gave enough time for learners to respond to her question, instead she went on talking*)*
>
> ***Learners:*** *(*no response but learners were laughing probably because she is asking the question very fast and repeatedly*)*
>
> ***Teacher:*** *It's a metal. So where do we put mercury here? (*teacher answering her question*)*
>
> After a minute the teacher went on with the lesson and said***:*** *When you look at the elements making up calcium carbonate, we have calcium, carbon and oxygen. What kind of substance is this? Where do we get that one ehhh? Where do you classify this, its an ionic compound. I've always said classifying substance is not complicated, you start by analysing the substance and then you ask yourself what kind of element is it made up of and then what kind of bonding you find in that substance?*

When the teacher asked about classification of salt solution in lesson 3 excerpt, learners did not respond to the question. The teacher went on to give an answer to the asked question but at the end of her answer she puts a question, "isn't?" to confirm with learners if they remember or agree with her on the reasoning she has provided but still learners were quite partly because the teacher did not give a chance for learners to respond. The continuous learners' lack of answers for example in the reasoning for salt solution to be classified as a physical change and classification of calcium carbonate, indicates the level of learners uneasiness with the content even though the teacher had taught about classification of physical and chemical change in the lesson prior this demonstration lesson. It could also mean that the phrasing of the question is a challenge for the learners or they did not understand when the teacher was theoretically teaching about physical and chemical change as it was the first time learners encounter this topic in Grade 10.

Thabo

In Thabo's classroom observations, he taught his first lesson (magnetic field of permanent magnets) through chalk and talk approach where he was asking questions to learners and then writing responses on the chalkboard and also used the board to write concepts of the content. Towards the end of his first observed lesson, Thabo used a worksheet for learners to engage in hands-on group work task, learners observing and practicing the idea of 'magnetic field'. The use of a worksheet seemed to be based on the purpose of the lesson being taught. The interactive nature of Thabo's lessons was due to the mixture of Teacher-Centered Approach (TCA) and Learner-Centered Approach (LCA) even though most of the times, teacher talk dominated. Moreover, question and answer approaches were used at various points to highlight and review learners' points of views, and was also used to lead learners in reaching one specific point of view (what science knows) after various points of views have been explained by the teacher. The following lesson 1 on magnetic field of permanent magnets:

> ***Teacher****: Have you ever seen a magnet before?*
>
> ***Learners****: Yes (responding in a chorus)*
>
> ***Teacher:*** *Do you know a magnet?*
>
> ***Learners:*** *Yes (responding in a chorus)*
>
> ***Teacher:*** *What are we using the magnet for?*
>
> ***Learner****: To attract things*
>
> ***Teacher:*** *To attract things. What do you think, what causes magnet to attract things? (No response). Is the magnet attracting everything?*
>
> ***Learners****: No (in a chorus)*
>
> ***Teacher:*** *Like she is saying, it can attract things. What happens when if something is attracted by the magnet?*
>
> ***Learners:*** *Inaudible*
>
> ***Teacher:*** *Its metallic materials, what else? Ironic materials. It means we are having some other materials that cannot be attracted by magnet?*
>
> ***Learners****: Yes*
>
> ***Teacher:*** *Can you give examples of those…*
>
> ***Learners:*** *plastic, rubber,*

Similarly, on the second observed lesson, Thabo used worksheets; chalk and talk approach but with the addition of analogies of an empty hall echo and mountain echo as a representation of reflection and refraction, see for an example the following excerpt:

> ***Thabo:*** *Have you ever been in an empty hall? (learners: yes) Some have been there before neh, what happens when you say whoooahh!! (making some sound) in that room. (learners responding but inaudible). You get echoes, echo of your voice, the same thing will apply when you go into the mountain and you make the same sound, what will you hear? You will also hear the echoes neh. Now scientifically, we are saying what cause those things, what cause the echoes? (learner: the sound bounce back). The sound bounces back, good. And when the sound bounces back which words scientifically can we use? We have got English way of mentioning things but there is scientific way of mentioning things (silence). Voices are bouncing back in English, scientifically what can we say? We have the so-called reflection and refraction remember those words, those are scientific words. (This explanation was followed by a drawing [see picture on section 5.2.1.1] to show these two words visually)*

The teacher used the idea of an empty hall and sound making resulting to echoes in order to illustrate the idea of reflection and refraction. While the teacher introduced the concepts appropriately by using both the everyday and scientific examples and clarified the differences in English language and scientific language, of concern is that the teacher did not specify what each word is referring to. By leaving the words unspecified it could lead to misconceptions that sound bouncing back means both reflection and refraction and these words have thin line in between such that if not explicitly explained they can be challenging to learners, especially in Grade 10 learners. Moreover, when the teacher asked for a scientific way of describing echoes, learners responded by saying "sound bounce back" and the teacher repeated after this response and acknowledged it as being good but also shows that there is still something more he is looking for through further probing. Thabo wants a certain terminology as he now says "Which words scientifically can we use", from this question it appears that learners were correct on sound bouncing back but that answer was an everyday way of explaining a phenomenon and now Thabo wants the scientific ways of explaining the same phenomenon. After Thabo has mentioned the scientific ways of explaining which are reflection and refraction, he does not then links the everyday way of explaining (sound bounces back) to the scientific ways of explaining (reflection and refraction) as suggested by Scott et al. (2011). Based on how Thabo engaged with the content of waves, in lesson 2, he demonstrated collaboration of learners' prior and everyday knowledge in his explanation, through the use of 'empty hall' analogy to exemplify sound reflection and refraction. Additionally, both Thabo's first and second lessons were interactive in

nature but located towards the authoritative end of interactive/authoritative dimension because the talk was controlled by the teacher. As such, Thabo's observations suggest that he uses mostly interactive/authoritative approach in lesson 1 and 2, with also the use of non-interactive/dialogic communicative approach in some instances during the lessons.

Simphiwe

Additionally, Simphiwe used more question and answer approach to interact with the science content and then learners. From the three teachers (Ayanda, Thandi and Simphiwe) already, question and answer approach appears common. The classroom interactions and talk of Simphiwe indicates that she is Subject-Matter Centered (SMC) because she was mostly concerned with the technical words of science, with little evidence of considering learner prior knowledge in relation to the taught content. For example in her observed lesson 1, the teacher read the textbook questions and started engaging with the content. The following excerpt exemplifies Simphiwe's teaching practice:

> ***Teacher:*** *(reading the question in the textbook) Number two, 100grams of sodium chloride is dissolved in 450cm^3. How many moles of sodium chloride are present in this solution? How do we calculate the number of moles?*
>
> ***Learners:*** *learners responding in a chorus (could not be captured)*
>
> ***Teacher:*** *N equals to… (*teacher writing the equation N=m/M on the chalkboard*). So you said when we calculate the number of moles, it will be mass over the molar mass. So how much is the mass of sodium chloride? And how did you calculate the molar mass (*No response from learners*)? The molar mass of sodium chloride would be what?*
>
> ***Learners:*** *23 plus 35.5 equals to 58.5g/mol. (*Responding all at once and considering the 3 asked questions above, the answer 58.5g/mol represents the third question "The molar mass of sodium chloride would be what?*).*
>
> ***Teacher:*** *So now that you have the molar mass, the mass it was given to be how much? 100 what? (*the teacher leading learners to provide a particular answer)
>
> ***Learners****: Grams*
>
> ***Teacher****: 100 grams divided by 58, 5, one coma…?*
>
> ***Learners:*** *Seven zero (*reading from their homework textbooks*)*
>
> ***Teacher:*** *Coma seven..? Some say coma seven one, some say coma seven zero. Ok let's use a calculator (*teacher reading her notes silently to confirm the above answer*) mine is one coma seven zero nine (1,709). So one coma seven one mol (1,71 mol). (*the teacher does not wait for learners to calculate and give her the answer but she gives them the answer and moves on*)*
>
> ***Teacher:*** *So the second one, what is the volume in water in dm3 ?*

Learners: Responding in a chorus and they could not be captured

Teacher: *Remember yesterday I said whenever you want to convert from cm3 to dm^3, what do we do?*

Learners: *We divide by 1000 (*in chorus*)*

Teacher: *We divide by 1000 (*emphasizing what learners have said*), so now they are saying what would be the volume in dm^3? It is give in cm3 it means you have to convert it into dm^3, how do we convert? (*the teacher writing the steps for getting into dm^3 on the chalkboard*). The answer? Its 0.45 dm^3 (*confirming the answer from her notes*)*

Teacher: *And the last one, calculate the concentration of the solution. What is concentration? (*no response*). What is concentration?*

Learner: *(*responding but in a low voice and could not be captured clearly*)*

Teacher: *She said it's the amount of the solute that dissolves in a solvent. So the concentration would be…(* going towards the chalkboard) *which formula do we use?*

Learners: *(in a chorus) C is equal to mass over MV.*

Teacher: *So that's the formula that we are going to use. How much is the mass?*

Learner: *100*

Teacher: *(*writing the whole calculation for learners on the chalkboard).*so what would be the final answer?*

Learners: *3.7..(responding in chorus and were not clearly captured)*

Teacher: *3, 799 (writing on the chalkboard). What is the unit? ….ehhhh?*

Learners: *mols per decimetre cube*

Teacher: *mols per decimetre cube ($mol.dm^{-3}$). Remember we said that an answer that does not have a unit is wrong. So is there anyone who don't understand what we have done so far?*

Teacher: *So is there anyone who got number C wrong? Or should we start by number one, is there anyone who got number one wrong (*learners responding*: No)? So we got that one right (*learners responding*: Yes). Number B? you got it right…so number C, some of you got it wrong*

Learners: *Yes*

Teacher: *Why? (no response).*

Simphiwe starts by asking a question to get learners understanding of the calculation for the number of moles. In some cases, learners responses are accepted without comment (we divide by 1000 and 3.799), at other times Simphiwe selects part of a learners answer (mine is 1,709),

which is then written on the chalkboard. In this way Simphiwe controls what appears on the chalkboard. She further follows up on the incomplete learners responses, 'what is the unit?', drawing attention to the calculated answer having units to be regarded as being correct. The teacher also asks 'is there anyone who don't understand what we have done so far?, even though the question is generic but it is clear that Simphiwe's talk here is interactive in nature though its controlled by the teacher and is located towards the authoritative end of the interactive/authoritative dimension. Interestingly, Simphiwe said "*calculate the concentration of the solution. What is concentration?"* Simphiwe asks about concentration but never asked about the meaning of solution as a EWS. Even on the answer provided by the learner, the teacher says *"She said it's the amount of the solute that dissolves in a solvent",* Simphiwe never commented on the wording in the answer but just left it there. So it is clear that the paths from everyday to scientific knowledge (science contextual language) for words such as solution, amount, and dissolves, as enacted on social plane was not completed by Simphiwe.

Moreover, the phrasing 'is there anyone who got number C wrong' suggests that Simphiwe is more interested with the content mastery rather than the procedures of knowing content. Moreover, the procedural nature of Simphiwe's teaching suggests that she focuses more on teaching her learners how to pass the science examinations, because she repeatedly emphasized that 'when this is asked in the exam then you have to do this'. The teaching approaches employed by Simphiwe appear to be influenced by her knowledge of SSMK and EWS.

Teaching towards examination is also argued by Khisty (1993) that teachers instil memorization rather than engaging with learners for science meaning-making. Interestingly, irrespective of participants being trained in a particular context (university or college), Question and Answer Teaching Approach (QATA) appeared dominant in all four participant teachers as indicated in Table 5.2.2. Although all participants involved a lot of questions and answers, there was very little probing of, and working with learners' ideas. However, the reason for this dominance could be the lack of resources (visual representations). Although QATA might serve a good purpose in the teaching and learning of physical science, but it seems to present science as the abstract and theoretical subject instead of being a practical subject. If rural context is seriously considered when teaching physical science, QATA could have been what was available to teachers to practice for the teaching and learning of science. Additionally, all participants engaged with their

learners mostly when learners had to answer questions, but of interest is that in most of the observed classrooms learners could not answer the asked questions; instead teachers would answer their own asked questions. Table 5.2.2 shows briefly the pedagogic approaches as employed by each teacher in each observed lesson.

Table 5.2.2 Summary of Teachers Pedagogic Approaches

Teacher	Lesson No.	Teaching Approaches					Communicative Approaches
		Pedagogic approaches		Resources	Representations		
Ayanda	1	Chalk &Talk	Q & A	Textbook			Interactive / Authoritative
	2	Chalk &Talk	Q & A	Textbook			Interactive / Authoritative
	3	Chalk &Talk	Q & A		Demonstration (practical work)	Simulation	Non-interactive / dialogic
Thandi	1	Chalk &Talk	Q & A	Learners drawing on the chalkboard	Poster (periodic table)	Analogy	Interactive / Authoritative
	2	Chalk &Talk	Q & A	Learners writing on the chalkboard	Poster (periodic table)	Analogy	Non-interactive / authoritative
	3	Chalk &Talk	Group work, Q & A	Textbook Worksheet	Ball and stick model (practical demonstrations)		Interactive / Authoritative
Thabo	1	Chalk &Talk	Group work, Q & A	Worksheets	Demonstration (magnetic field)		Interactive / Authoritative
	2	Chalk &Talk	Q & A	Worksheets	Analogy		Non-interactive / dialogic
Simphiwe	1	Chalk &Talk	Q & A	Textbook			Interactive / authoritative
	2	Chalk &Talk	Q & A	Textbook			Non-interactive / authoritative

Note: Q & A = Question and Answer; Lesson No. = Lesson number

5.2.2.1 Teachers' explanation or lack thereof of everyday words used in science context

Despite the general teachers' pedagogic approaches to physical science teaching, teachers also need classroom context-based pedagogic approaches in addressing the usage of everyday words in science classroom context. From the findings of this study, participants were observed dominantly explaining the technical words or words that appears to be important for the understanding of science content, and overlooked clarifying to learners the everyday words used in science context which are also important in understanding science content. Technical words are important because they give an identity to physical science discourse and it is what science

teachers are supposed to teach but of importance is that for technical words to be accessed and be taught, teachers use non-technical including EWS as conveyor belts of meanings (Ncube, 2014). From the classroom observation, teachers provided explicit meanings of physical science words such as: alloys, element, atoms, inert, reflection and refraction, which were read from the textbook and these were the science concepts to be taught and they were explained explicitly as follows.

> **Ayanda**: *Remember last time I told you about this, **alloys,** I said alloys are mixtures, they can be mixtures of metals and other substances like carbon but in most cases its metals which are used to make what alloys*.
>
> **Thandi:** *What are these **atoms**? (teacher responding) small building block of matter (teacher writes this on the chalkboard). An atom is described as the smallest building blocks of matter.*
>
> **Thandi:** *I like another definition which says when you define **element** and a compound, it says element is substance that cannot be broken down, a substance that cannot be broken down into simpler substances but that one of Happy, a compound is made of two or more elements (teacher writing on the chalkboard).* [The underlined signifies the explicit explanation of the used words]

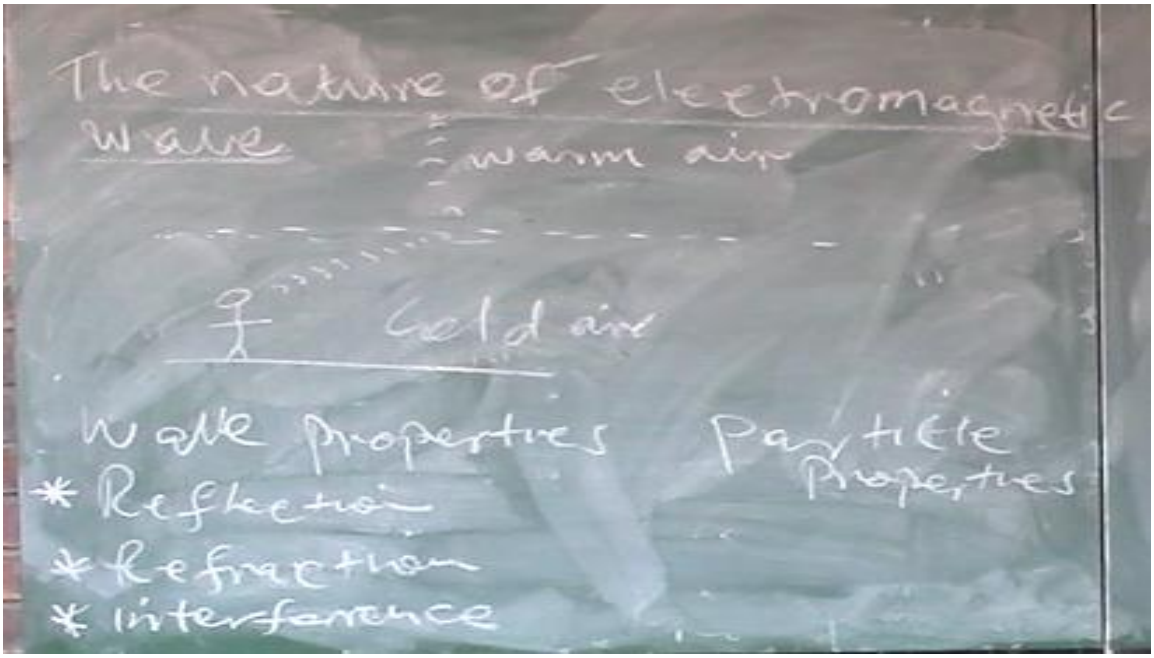
Above teacher's talk indicates the explanation of meanings of the technical words such alloys, atoms, and element. Of importance with the given explanations is that the words are explained explicitly, and learners are very unlikely not to get the meanings of the technical words as communicated by the teacher on social plane. Moreover, with the explanation of everyday words used in science context, words such as inert, reflection and refraction have been explained implicitly below; because their meanings (explanation) were embedded on teacher's talk. The implicit explanation of these words links to what Halliday (1993) referred to as "interlocking" being the tendency of explanations of certain words being embedded in explanation of other words, or in the teacher talk. Following are the classroom teaching episodes where the non-technical words (including EWS) were explained implicitly, assuming that learners would derive meanings of words from the given explanation of content:

> **Thandi:** *Helium, neon, argon and the likes, elements of group 18*[31]*, why because they are called, we call the elements of group 18 **inert**, meaning they are rich, they are rich. They've got eight*

[31] Group 18 elements: Drawing from the researcher's experience, when I was doing grade 10-12 physical science at school, we were taught that periodic table has 18 periodic groups, group 18 being currently known and taught as group 8 in the South African syllabus under CAPS. This is the group of noble gases.

valence electrons but these ones (pointing at group 17 elements) they are not that much bad, these ones (group 18) are like 'Motsepe[32]' they don't want anything.

Thabo: *We have got English way of mentioning things but there is scientific way of mentioning things (*silence*). Voices are bouncing back in English, scientifically what can we say? We have the so-called* ***reflection*** *and* ***refraction,*** *remember those words, those are scientific words*. [This explanation was followed by a drawing below to show these two words on the chalkboard]



From the explanation of reflection (EWS) and refraction (technical word), the teacher did not make it explicit to say what he referred to by the phrase 'sound bounce back'. In the above teaching episode, while the meanings of inert and reflection as non-technical words were provided, though at times implicitly, the explicit explanations were mostly given to the technical words (alloy, elements & atoms) that are used more often in the physical science register. Even though it is understandable that teachers want to ensure that learners understand the meaning of science concepts or words (technical), they overlook the significance of explaining EWS. Thus, teachers possibly explicitly explained (reading the definitions from the textbook) technical words to enhance learners' and the teacher's understanding of physical science content knowledge, which is fundamental because it introduces learners into the science community of practice, to

[32] Thandi compares the stability of noble gases to Motsepe. Patrice Motsepe is South African mining magnate. Motsepe is the founder and executive chairman of African Rainbow Minerals (https://www.forbes.com/profile/patrice-motsepe/).

what science knows, it is of concern that EWS which is part of STL was left unattended. However, I observed that most of the participants did not provide meanings of everyday words used in science context. In the observed analogies about echoes, the teacher did not explicitly and specifically link either reflection or refraction to the idea of sound bouncing back because the two words do not mean the same thing. The used analogy has a potential for causing learner misconceptions on the words reflection being the same as refraction and this is also supported by Louisa, Pereira and Maskill (1989) who argues that more often learner misconceptions are embedded in the linguistic analogies and metaphors used by teachers when discussing with learners.

I also noted from Simphiwe's lesson that she explained the technical word 'combustion' and did not explain EWS such as prepare, solution, amount and other EWS. When she was explaining combustion, she explained it as follows "combustion is actually the burning of substances in air, or when you burn the substance in the presence of oxygen, that is combustion. "During the interview she noticed the need to have explained some of the EWS that were left unattended during her lessons. I asked Simphiwe the reason for explaining 'combustion' and she said:

> *…So you won't get the chemical reaction right, meaning you have to understand each and every word in the question in order for you to be able to answer it. That was the reason why I explained it because it was for the first time we talk about combustion in grade 10, but we did it in grade 9, obviously they have forgot it…*

The phrase "*you have to understand each and every word in the question*" suggests the participant was aware of the need to re-explain the meaning of words rather than take it for granted that learners' still remembers it. The excerpt above also indicates the irreplaceable functional value of words and therefore each word including EWS has to be understood correctly within the boundaries of where the word is used.

Since the observed lessons were science lessons, the science teacher cannot explain the non-technical words including EWS away from the technical words. However, this study foregrounds the analysis of non-technical words including EWS in understanding how the use and explanation of everyday words could possible enhance the teaching and understanding of technical words.

Thandi

From the observed classroom lessons, Thandi explained one everyday word used in the science context, the word 'matter'. Of concern however, is that the word 'matter' can be considered a level one word according to Wellington and Osborne (2001). Level one word means this word is identifiable with science content, observable and real (Wellington & Osborne, 2001). The word was explained as follows:

> **Thandi**: *What do you understand by matter?* (Learners responded in a chorus making it inaudible to be captured).
>
> **Thandi:** *Anything that can be able to occupy a space and has mass, when you see that thing is matter from the previous knowledge, from grade 7. Then matter has got its classifications, phases, Thabo (not learner's real name) can you give one phase of matter, maybe just to remind you there are three phases of matter….(no response) lets assist Thabo. Yes solid is one phase of matter, solid. Thabo can you give us an example of a solid, its fine take time I will come back to you.*

Even though there is no set guides for teachers that they are supposed to differentiate between meanings of the words they use but in case a word has more than one meaning according to contexts, the teacher as the language teacher should differentiate between science context meaning and everyday meanings. From the above Thandi's excerpt, she did not discuss the other contextual meanings of the word matter but explained according to science. In her explanation of matter suggests that she was not able to differentiate between the meanings of everyday word usage and that of science context. Scott et al. (2011) argues that learning science involves making links to '*differentiate'* the scientific way of explaining from everyday views because of difference in ways of explaining based on the context of the explanation, so it was equally important for the teacher to explain what matter is not. Besides Thandi's attempt to explain the word 'matter', there is no evidence of other teachers' efforts or explanation of the everyday words used in science context. Of interest is that only during interviews all participants spoke of various strategies they use in dealing with language issues, especially everyday words in science classrooms. This contrast in classroom teacher's practice and teacher's responses during the interviews suggest that teachers who participated in this study do not know how to help their learners in understanding the language of school science including EWS (Christie, 1989). This discrepancy could also suggest teachers' ignorance of language issues, especially EWS, and that

participant teachers became, to some extent, conscious of the possible functional value of especially EWS during interviews.

Simphiwe

Along the same line of discussion, Simphiwe expressed theoretically during interviews a way of dealing with the difficulty of everyday words in science context. I refer to theoretical because from Simphiwe's two observed lessons, there was no evidence of attempting or explaining everyday words used in science context. Yet during the interview when I asked Simphiwe about the strategy or approach that she uses when encountering everyday words in her science class, she explained in detail:

> *…I asked them now when we talk about spontaneous what do we talk about? What are we actually talking about, a lot of them did not even know like they don't understand. Kere (I say) ok I will give them an example,...I was like when somewhere on twitter, on facebook or any in these social media, when they ask you to define yourself, you will be saying I am spontaneous. Ok but what does that mean…what does it actually means now in science text?*

The above excerpt does not show the observed teacher talk but she said this is how she taught the EWS spontaneous to a Grade 12 physical science classroom. According to the excerpt above, Simphiwe appears to know the multiple meanings embedded in words, especially the everyday words that are now used in science context. The response also suggests that she links everyday words to their use in the everyday context, and then look at the meanings of the same word with regard to the science context in which it is now used. Interestingly however, there is no evidence from her observed classroom lessons that Simphiwe explain or attempts to explain everyday words used in science context. This shows a disjuncture from what is taught and what is said to be taught, hence the importance of both classroom observation and the interview as methods of data collection especially in this study. During classroom observations Simphiwe seemed to be more concerned with what science knows, which is mostly the technical words of science, and no evidence shows Simphiwe's engagement with everyday words' meanings in the science classroom.

Thabo

Moreover, Thabo also seemed to confuse everyday words used "in" science (non-technical) with everyday words used "as" science (technical). This was seen when asking whether or not Thabo highlight the meanings of words used in science text or talk, he said,

> *Usually I explain terms, then at times I give them some work to go and do based on that. And then when I come to re-mark that work I'll also be highlighting to say this one did not use much of scientific concepts. As we move, you will even hear from themselves comparing their books to say I know you, you use only English not scientific terms.*

The response suggest that Thabo focuses more on the use and explanations of the "*scientific concepts*" which seems to be more of technical words which raises concerns about his knowledge of or differences between technical and non-technical words of science. Thabo alluded that he explains the words that he uses in class and also gives tasks to emphasize the understanding of these words, but during lessons Thabo left the everyday words in science unattended.

Ayanda

Furthermore, Ayanda's approach to language issues is quite different because of the usage of mother tongue language, though she explains the words, but she said she also allows the use of mother tongue language to 'simplify' the words or concepts at discussion. Ayanda said:

> *What I normally do is, I ask amongst the learners, I know some got it, if he has or she has understood the concept then I ask her or him to explain in their mother language to the other learners*

Ayanda's strategy suggests that learners understand science better when code switching to their home languages, even though it did not come out clear on how the use of home languages facilitate the 'simplification' of wording or concepts used in the science classroom. The issue of code switching is still contested in science education (Dlodlo, 1999; Oyoo & Semeon, 2015), because science is a language and it has its own language (Lemke, 1990). In another interview episode, Ayanda argues that she emphasizes on language issues in her classroom but also encourages the use of a textbook for science terminology. She said,

> *In most cases I emphasise that they must continually study, they got their textbooks, in a textbook they do use scientific terms, it's not plain English, they use scientific terms, I do encourage them to study, the more you study the more it can stay in your memory. But the problem which I noticed, the learners do not study.*

Given that the teacher noticed that learners do not study, it is unclear why she does not explain the everyday words used during her science teaching, because these are the words which learners are mostly familiar with outside science context and therefore negotiating meanings of the same word could be a challenge. What seems to emerge from Ayanda's explanation is the overwhelming prioritisation of science technical words because they are assessed explicitly and learners need to know the meaning of them for epistemological access in science. While on the other hand, the camouflage nature of everyday words used in science context is taken for granted hence the greatest difficulty it poses to the user (science learner) (Cassels & Johnstone, 1985; Tao, 1994; Ncube, 2014; Oyoo, 2017).

5.2.3. Teachers' awareness or lack thereof of the difficulty posed by everyday words used in science context

A second sub-theme emerging from both classroom observation and interviews was *Teachers' awareness or lack thereof of the difficulty posed by everyday words used in science context.* This sub-theme addresses teachers' level of awareness or unawareness of the language difficulty during teaching. The sub-theme discusses significant issues within science education context, because discussions on the difficulty with STL, precisely the EWS has been ascribed to general proficiency with English (LOLT) (Bird & Welford, 1995; Dlodlo, 1999; Rollnick, 2010), and has been related largely with learner familiarity with issues of science school language (Muralidhar, 1991; Ncube, 2014; Ncube, 2016). The findings of this study indicated that participants were unaware of the functional value and the difficulty posed by EWS. During teacher interviews, the participant teachers largely associated difficulties with teaching and learning physical science to learner poor proficiency in English language as LOLT (to be discussed in section 5.4.1); learner difficulties in understanding science concepts (difficulty of the subject); lack of learner discipline (poor self-study); and lack of chemicals (materials) for science practical work. During the interviews, teachers said:

Ayanda: *Even when I taught them last term I told them we can get back these things, ahhhh they said no no no you are lying. But if we can demonstrate it, if we have a Bunsen burner, one time we collect a Bunsen burner, in no time, ten minutes, the water has evaporated they see, they do it now they believe. Up to now they don't believe distillation, if we had a distiller they would see the process happening if they can test the water if we have clean equipment, to see… you saw that guy he said you mean that water doesn't have salt, he doesn't believe it. It's now pure water, water only, the salt has remained in this beaker….The main reason, number one, it's discipline… From the learners side, I can say that, their*

English is very bad … language it does contribute again to the performance of a learner… But the problem which I noticed, the learners do not study.

Simphiwe: *One of the challenges that we have like when teaching science you need materials. Cause some of the lessons might be practical, we cannot always be talking theory theory sometimes you must do practicals in class, like kids learn how to create their own understanding.*

Thabo: *Learners take time to understand science concepts*

Thandi: *You can see that they merely capture all what you are saying but in response*

Lack of practical work was viewed by Ayanda and Simphiwe as the major factor for the low status of physical science. Even though from my school observations, I noticed that Ayanda's school had science apparatus for practical work but was unmanaged, and the laboratory room is used as a classroom while the chemical store room is used to store learners' textbooks due to space shortage. Of interest however is that some participant teachers did not view learner difficulties in learning physical science to be stemming from the difficulties encountered with the contextual meanings of EWS, but from difficulty of science as a subject, lack of resources for practical work, learners' lack of self-study (above). This seems to suggest that some participants were generally unaware of the functional value of everyday words used in the science classroom.

Specific evidence could be that of Thandi's response concerning the observed challenges with language issues when marking learner scripts or during teaching. Thandi said that "*with me, I don't have much difficulty with my learners*". When further probed if learners encounter any possible challenges with the words used in science classroom (science text) which are also used in normal (everyday) English, Thandi openly said: *"No, I don't think it may be there"*. Thandi alludes that there are no challenges with normal or everyday English words used in science classrooms. This response raises questions of whether the teacher is not aware of the general difficulty of normal English words used in science context, or she has not observed any difficulties with her learners because it is not yet clear whether or not her learners also encounter difficulties with EWS. Above all this, Thandi's response revealed her lack of awareness of the place of normal or everyday English words used in science context for enhanced learners' understanding of the science concepts.

On the other hand, Ayanda, Simphiwe and Thabo noted that they have observed some language difficulties in the assessment and during teaching and learning processes. When asking Ayanda if she has observed these language difficulties, specifically the EWS, she said:

> *Yes. I see that because there are times they're asked to describe this, you see their answer uses plain English because it will be (*inaudible*)…you can see more, the learner is supposed to have done so*

In this response, Ayanda admits that learners have language difficulties in physical science classrooms as they use mostly "plain English". The use of 'plain English' could imply that everyday words used in the science context are mostly understood according to their normal or everyday English meanings, irrespective of the science context in which these words are now used.

Similarly, during the interview Simphiwe mentioned that she observed learner difficulties with everyday words when used in science context, she said:

> *Other than saying that a reaction that happens on its own, so now a child, I remember in Grade 12 this year I asked them now when we talk about spontaneous what do we talk about? What are we actually talking about, a lot of them did not even know like they don't understand kere (I say) ok… to define yourself, you will be saying I am spontaneous. Ok but what does that mean… I see them a lot of times but what does it actually means now in science text*.

The above response of Simphiwe suggests that she is to some extent aware of certain everyday words in science which could pose a difficulty or be a barrier in learners' learning of science. However, Simphiwe did not explain the EWS in the Grade 10 classroom, which indicates that she values more Grade 12 (because they are the image of the school) than laying physical science foundations at Grade 10. It can be argued therefore that for Grade 12 learners need to be prepared more for external examination; hence much attention is paid to them while the foundation of physical science (Grade 10) is not given much attention, in terms of conceptual understanding of words that makes up science and the words that facilitate the science understanding. Probably, part of the reason why Simphiwe's Grade 12 "*did not even know like they don't understand"* what spontaneous means could be the taken for grantedness of EWS at the foundational phase of physical science (Grade 10).

5.3 The key to understanding a subject is to understand its language: Nature of EWS usage

Part of the reasons physical science teachers need to build science vocabulary during their teaching is that more often they use polysemous[33] words in their teacher talk. Familiar words that are used in everyday conversations are also used in science classrooms, but assume new and precise meanings when applied in science context. Some of the polysemous words include; power, energy, force (technical) and reactions, solutions, spontaneous (non-technical: EWS) and EWS are linguistic devices employed to convey scientific meanings, which if understood could possibly enhance the way science is conveyed and comprehended. This study focused specifically on everyday words when used in science context within the non-technical words because literature indicates that contextual meanings of EWS pose a difficulty to science learners (Tao, 1994; Ncube, 2014; Oyoo & Semeon, 2015). As pointed out in section 4.9 and 4.10, to obtain EWS from classroom observations, I read through the observation transcripts being guided by Oyoo's (2012; 2017) descriptions of everyday words in science context. In reading through the transcripts, I also referred to Tao's (1994) and Cassels and Johnstone's (1985) classification of non-technical words including EWS in order to comprehensively identify and study EWS among other words. The Tables 5.3.4.1 – 5.3.7.2 (from section 5.3.4 to section 5.3.7) represent an analysis of each participant teacher's usage of everyday words in physical science classrooms during the observed participant lessons. This is followed by the discussion of each teacher's actual usage of two EWS from the observed lessons.

From the classroom observation, there was a varied nature of the everyday words used in science context during participants' teaching. The theme is about teachers' interpretation (during interview) of the observed (during classroom teaching) EWS. The theme was analysed according to three underlying categories which emerged from the data and these were *'self-explanatory assumptions on EWS', 'text-embedded explanation'*, and '*comprehensive nature of EWS*'. The first category '*self-explanatory assumptions on EWS'* discuss teachers' assumptions for not interpreting some of the EWS used in their classroom teaching. Category two '*text-embedded*

[33] "Polysemy is the semantic term indicating that one word is used with two or more interrelated meanings, making up a set of meaning variants" (Strömdahl, 2012, p.64). In this study polysemy will also refer to multiple meanings of a word and these multiple meanings are dependent on the context in which that particular word is used.

explanation' details teachers' implicit interpretation of EWS during teaching and the last category '*comprehensive nature of EWS'* signifies teachers' explicit interpretation of EWS used during their teaching. The following discussion presents briefly the three categories as identified in terms of meditational practices, and then examine carefully each teacher's practices according to his/her EWS used during teaching.

Often participant teachers assumed that there is shared understanding of the meanings for some EWS used during their teaching. As such teachers did not implicitly or explicitly interpret most of the EWS used in their lessons. By not mediated, I mean that teachers only used these words without providing (meaning differentiation / integration) either explicit or implicit meaning (s) of each word as used according to the science context. In some teaching segments, teachers appeared to be unconscious of the explanation EWS, where they did not verbalize that this EWS means this or that but the explanation of the meaning (s) of the EWS was embedded in the teacher talk. These instances indicated teachers' implicit mediation of EWS. Moreover, rarely did teachers explicitly explain the meanings of used EWS during teaching. This means most of the EWS used in the observed lessons were not explicitly mediated for learners' meaning-making. Explicit mediation signifies teachers' explicit interpretation of EWS used during their teaching and it refers to the conscious act of the teacher to use science contextual language including EWS, hence clearly giving an explanation of the meaning (s) of used EWS by stating that this EWS means this or that. This act was at its minimal practice from the observed teachers' lessons. The findings suggest that occasionally, teachers viewed some EWS as requiring comprehensive understanding hence explicitly explaining these words. The following discussion presents each teacher's use of the EWS during teaching.

5.3.1 Ayanda's use of everyday words in science

Ayanda was observed teaching two topics: 'Atoms and Compounds' and 'Physical and Chemical Change' in Grade 10 physical science classes. During her teaching, I noted different EWS that she used. Of the everyday words in science context used by Ayanda during her physical science lessons (in Table 5.3.1.1 below), I have selected five everyday words in science context (due to scope and space of the study) to show how these words were used in the context of the observed classroom lessons, and whether these words were explicitly or implicitly interpreted or not interpreted according to context of their use.

Table 5.3.1.1.Summary of everyday words used in science teaching during Ayanda's lessons

Everyday words in science		
Charge	Destruction	Encounter
Structure	Products	Properties
Matter	Common	Network
Levels	Nature	Symbol
Stable	Decompose	Forms
Reaction	Deposition	States
Shell	Corrosive	Composition
Determined	Phase	Noble
Participate	Solution	Mixture
Satisfy	Uniform	Arrangements
Pure	Release	Screens

Table 5.3.1.2 shows the five selected everyday words during Ayanda's physical science teaching. For the overall analysis, of the five selected words from each participant teacher, I have further selected two words per teacher to critically examine each word usage. These two carefully selected EWS are words that:

- Appears across participant teachers teaching (in more than one participant teacher's teaching).
- Appears the most in the individual teacher's lessons.
- Was asked about during the in-depth individual interview with the teachers.
- Seems to have posed a challenge to learners during teacher's teaching or that seems to require special attention based on how the wording was used during teaching.

Table 5.3.1.2 suggests that majority of the everyday words when used in the science context by Ayanda were not explained according to their use in the specific physical science classroom context.

Table 5.3.1.2 Contextual use of some everyday words in science teaching during Ayanda's lessons

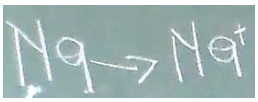
Mediation	EWS	Teacher excerpts
Implicit mediation	Structure	What change in electron *structure* occurs when a sodium atom becomes a sodium ion? 'What change in electron structure occurs' (*emphasis*) remember we did electron configurations, electron configuration that is electron structure or the arrangement of electrons in an atom.
Non-mediation	Noble	Right ehhhm, argon is a noble gas that is found in group eight. It's a *noble* gas, remember when we were talking about mono atomic elements and di atomic, do you remember that? Mono atomic elements and di atomic elements, mono I said the word mono means what? (learners: one) it means one, so they consist of single atoms, they exist as single atoms.
Non-mediation	Uniform	This is salt dissolved in water it forms a salt solution, salt solution. This is one of the homogenous mixtures isn't it? Remember homogenous mixture it has got a uniform composition and uniform colour isn't it? Now you can't even see the salt it has completely dissolved, so we are saying this is one example of a physical change.
Implicit mediation	Participate	Remember when you learnt about reactions…I mean chemical bonding in the first term, we said it is only the electrons out of the three subatomic particles, its only the electrons that participate in chemical reactions but the protons and neutrons because they are in the nucleus they do not participate in the chemical reactions. It is the electrons that participate in chemical reactions. That means it is the electrons that move from one atom to another and the neutrons and protons which are in the nucleus, they do not participate in chemical reactions.
Non-mediation	Stable	We also talked about the octet rule, remember the octet rule say that these elements react because they want to satisfy the octet rule and the octet rule says an atom is only stable when it has got eight electrons in the outermost shell, eight electrons in the outermost shell. So sodium when it has lost one electron, the outermost shell now has now eight electrons and chlorine it has seven electrons before it reacts so when it accepts the single electron now it has got eight electrons. Right and then emhhhh G says chlorine melts at minus 101 and sodium chloride melts at 801 degrees Celsius. What does this information tell you about the *structure* of each substance, the structure of each substance?

5.3.1.1. Ayanda's usage of the word 'Structure'

During one of the observed lessons, the teacher said:

> *What change in electron structure occurs when a sodium atom becomes a sodium ion? 'What change in electron structure occurs' (emphasis) remember we did electron configurations, electron configuration that is electron structure or the arrangement of electrons in an atom*

From Ayanda's utterances it is apparent that she implicitly explained structure by referring to electron 'structure' being the arrangements of electrons in an atom, however this interpretation of structure seems to have not been understood by learners. The reason is because when asked about the change in electron structure, that is, when is sodium atom becomes a sodium ion? Leaner's answer below:



The learner's answer shows confused meaning of the 'structure' with the everyday word used in science 'charge', which addresses a teacher's need to constantly and explicitly explain the everyday words' contextual meanings during science teaching. Learner's misrepresentation of information resulted to a teacher giving the answer below:



The teacher's explanation, Na is the atom and $1S^2\ 2S^2\ 2p^6\ 3S^1$, is the structure of sodium, while this is in fact electron configuration. The meaning of the structure was not explicitly explained in this lesson, as some of the learners might know from life sciences that a 'structure' (cell structure for an example) means that you have to represent the cell diagrammatically showing its nature (how it looks like). But in this lesson (quantum chemistry), electron structure meant electron configuration as the teacher wrote on the chalkboard but never mentioned this to the learners. The lack of explicit explanation suggests the presence of silent neglect on the functional value of everyday words when used in science context, and is worrying because EWS acts as a conveyor belt of meanings within science classrooms.

Important to note is that 'structure' also means different things within physical science text, because there is Lewis structure (Grade 10) which depicts the arrangement of electrons in an

atom but presented diagrammatically and differently from the Na $1S^2$ $2S^2$ $2p^6$ $3S^1$ teachers explanation. So the contextual meanings of structure according to topics within physical science signals a need for special attention to interpretation or differentiation in meanings of everyday words used per physical science topics as well. While on its everyday usage, the word structure refers to the particular arrangements of parts for something; a thing that is made of several parts; a state of being well organized; it also refers to arranging or organizing something into a system or pattern; and is also associated closely with framework and form. All these everyday understandings of structure could be the alternative meanings that are attached by learners due to the absence of physical science based interpretation of the word by the teacher.

5.3.1.2. Ayanda's usage of the word 'Stable'

During teacher talk, Ayanda used the word 'stable' when talking of the octet rule, and the English dictionary explains stable as something firmly fixed, something that is unlikely to move, change or fail and also refer to someone who is calm and reasonable; and also refers to a group of people who work or trained in the same place (Stevenson & Waite, 2011). However in the physical science context, stable refers to staying in the same chemical or atomic state especially in the topic "spectroscopy" (spectroscopic electron configuration notation in Grade 10). In the context of Ayanda's lesson stable was used as follows:

> *We also talked about the octet rule, remember the octet rule say that these elements react because they want to satisfy the octet rule and the octet rule says an atom is only stable when it has got eight electrons in the outermost shell, eight electrons in the outermost shell".*

The above excerpt suggests that Ayanda gave the condition for 'stability,' but did not explicitly explain what stable refers to in her context of the lesson. Thus the participant teacher did not effectively explain the meaning of the word stable, for learners to understand the condition of an atom when it has eight valence electrons. When asking the teacher about her meaning of stable that she wanted her learners to grasp, Ayanda said stable means that the group eight elements: *"they got eight electrons in their outermost shell that's why they are unreactive"*. This means that Ayanda associated stability (stable) with 'unreactive' elements, and this was not made apparent to the learners but only through interviews. The teacher seems to know the science contextual meaning of stable but did not explain this meaning so that there would be shared meaning of the word (stable) that convey science contextual use.

5.3.2. Thandi's use of everyday words in science

Thandi was observed teaching the topic: 'Atoms and Compounds'. While she was teaching, she used both everyday words as science concepts and everyday words in science context. Of the words used I noted the everyday words used in science context. Table 5.3.2.1 shows the everyday words in science context used by Thandi during her observed lessons.

Table 5.3.2.1 Summary of everyday words used in science teaching during Thandi's lessons

Everyday words in science		
Pure	Matter	Properties
Scale	Chain	Levels
Reading	Reaction	Conductor
States	Lattice	Charge
Balancing	Regular	Phases
Action	Held	Model
Transformation	Method	Occupy
Moment	Inert	

Out of the identified list of everyday words used by Thandi during her physical science lessons, five everyday words have been selected to show how these words were used in the context of the observed classroom lessons and whether these words were explicitly, implicitly or not interpreted according to context of use. Table 5.3.2.2 shows the five selected everyday words during Thandi's physical science teaching.

What transpire from Table 5.3.2.2 is that the teacher assumes meanings of everyday words used in science context to be obvious to the learners, without paying attention to other contextual use of the same word and how it differs or relate with science contextual meanings?

Table 5.3.2.2. *Contextual use of some everyday words in science teaching during Thandi's lessons*

Mediation	EWS	Teacher excerpts
Explicit mediation	Matter	What do you understand by matter? *Learners responded in a group and they were inaudible to be captured.* **Teacher:** Anything that can be able to occupy a space and has mass, when you see that thing is matter from the previous knowledge, from grade 7.
Non-mediation	Reaction	When they say hydrogen react with any element, when you write that hydrogen symbol, it must have 2, it's a golden rule.
Non-mediation	Phases	Then matter has got its classifications, phases, Thabo (*n*ot *learner's real name*) can you give one phase of matter, maybe just to remind you there are three phases of matter….(no response) lets assist Thabo. Yes solid is one phase of matter, solid. Thabo can you give us an example of a solid, its fine take time I will come back to you, eg. Diatomic or binary, DI, its not die but di and bi BI, what does this two means…? Bi, di… what does this mean (silence). Di means (*learners finished and said ONE*) di means one (*teacher probing further*)… *learners showing mixed answers, whether 1 or 2*… two (*the teacher says*). Mono means one, then binary, di means two, for example, eg we've got seven binary molecules or binary atoms. Zama (not learner's real name) can you give us three phases of matter, the three phases of matter that you studied in grade 7, grade 8, you can call them phases or states there are three. Zama! ***Zama:*** *metals, semi-metals and non-metals (the teacher was saying these after the learner)* **Teacher:** Metals, semi-metals and non-metals, three phases of matter, it's a try akere (isn't) and what I like with that he gave science answers not give us ehhhhh technology answers or maths answers. Phases of matter…(*the teacher pointing at another learner without clearly telling learners whether the first answer given by Zama is correct or wrong for the question she is asking*)
Non-mediation	Model	How can we represent these compounds, we've been talking about compounds, compounds, compounds can be represented in two ways, we can use ehhhm ehhhm a method which is called a ball-and-stick model, …..*silence*….what do we call this model? *The teacher responding together with learners*: a ball-and-stick model. The other one is space filling model.
Implicit mediation	Transformation	***Learner:*** *we can classify water into solid when it turns to ice, and when water is boiled the vapour…(incomplete) and when you smell, melts* **Teacher:** its transformation, when you take the same water which you said it is liquid you put it in a refrigerator, in the deep freezer, it freezes, it changes from liquid to solid. And when you want to reverse the ice to liquid what do we call the process we did it in the first term? Precious!

5.3.2.1. Thandi's usage of the word 'Reaction'

The word reaction has varying meanings according to its contextual use and it is necessary that the meanings are made known according to a specific context where the word is used. Stevenson and Waite (2011) explain reaction as something that you do, say, or think as a result of something that has happened (*situational context*); it refers reaction to a change in people's attitudes or behaviour caused by disapproval of the attitudes of the past; it refers reaction to a response by the body, usually a bad one, to a drug and chemical substances (*biology context*); and also refers reaction to the ability to move quickly in response to something, especially if in danger. In the chemistry strand of physical science, reaction often refers to a chemical change produced by two or more substances acting on each other (chemical reactions or nuclear reactions) while in physics strand of physical science, reaction refers to a force shown by something in response to another force, which is of equal strength and acts in the opposite direction (Stevenson & Waite, 2011). During the classroom teacher talk, reaction was used as follows: *"When they say hydrogen react with any element, when you write that hydrogen symbol, it must have 2, it's a golden rule"*.

The teacher used react (verb) instead of reaction (noun denoting a chemical process) and its meaning was not explicitly explained to the learners. When further probed if there was anything she wanted her learners to know about reactions and about what she meant by reactions during her lessons, Thandi said:

> *Not necessarily, but when we talk about reactions with my learners maybe taking one element reacting it with another, it will give us or yield a certain product but we have others which cannot yield any, when Sphamandla I can't even give you the correct answer, but what I normally use is that when I react elements of this group, then that one they will give me this. That particular product, maybe from there you balance but maybe sharing it with learners, so that I can come to an understanding…*

Firstly, the teacher clearly state that there was nothing she wanted her learners to know specifically about reactions, because she seems not to know what reaction means in the context of science and this is mentioned in this response "… *I can't even give you the correct answer…"* of what reaction means in science context. This is distressing because the meanings of reaction changes across and within physical science contexts, because in physics reaction is a technical term but in chemistry reaction is an EWS used to describe what happens when two or more substances are mixed (Oyoo & Semeon, 2015). Furthermore, Oyoo (2012) concurs that when

words such as *reaction* are used within the science context they embodies certain concepts that are important to the processes of teaching and learning specific chemistry content within physical science. So lack of understanding and explicit explanation of reaction could be a barrier into learners learning of science concepts embodied in reactions. In addition, the teacher seems to associate the word reaction to products, even though there is no clear indication of how the two were compared.

Lastly, due to teacher pronunciation and the fast teaching pace, some words were not clearly articulated or were said swiftly. For example, when referring to reaction the teacher (Thandi) spoke of 'action' instead of 'reaction' as follows: *"…molecular electrons are shared between the non-metals while in ionic they are solid that results from action of metals and non*". The word action is what was captured during the teacher's classroom teaching, and if captured properly it can mislead the learners in understanding reactions since action and reaction have different meanings and implications in learning science.

5.3.2.2. Thandi's usage of the word 'Phases'

In one classroom observation, Thandi used the word 'phases' to refer to themes of matter, but initially the word phases seems to have been used similarly with classifications. This can be seen for example during Thandi's lesson when she said:

> *Then matter has got its classifications, phases, Thabo (not learner's real name) can you give one phase of matter, maybe just to remind you there are three phases of matter….(no response) lets assist Thabo. Yes solid is one phase of matter, solid. Thabo can you give us an example of a solid, its fine take time I will come back to you.*

The word 'phases' seems to have not been explained according to its context of use and this might have implications on learners learning of the physical science content. The word phase when said quickly, as was done during teaching, might be mistaken to its homophonic word 'face', especially when this word (phase) is not written down or it is the first time the teacher talks about it in class. Interestingly however is how the teacher explained the following words (homonyms) yet the word phases (which sound like faces) was not fully engaged with.

> *eg. Diatomic or binary, DI (pronounced as die), its not die but di and bi BI, what does this two means…? Bi, di… what does this mean (silence). Di means..? Mono means one, then binary, di means two, for example, eg we've got seven binary molecules or binary atoms.*

Thandi chooses which words to explain during teaching and more often those words associated with what science knows are the ones enjoying explicit interpretations during most of her lessons. Lack of teacher's explicit interpretation of the word 'phases' might not lead to holistic and effective learners learning of the content, because the word have different contextual meanings which learners might come into class with. The everyday meanings of the word phase differ according to the context of the word usage. For example, Stevenson and Waite (2011) refer to phase (noun) as a stage in a process of change or development; phase (verb) refers to arranging to do something gradually in stages over a period of time. These everyday contextual meanings are important to be kept in the teacher's mind during the teaching of 'phases' of matter.

5.3.3 Thabo's use of everyday words in science

Thabo was observed teaching the topics: 'Magnetic Field of Permanent Magnets' and 'Electromagnetic Radiation: Nature of Electromagnetic Radiation'. While teaching both lessons, Thabo used certain everyday words in science context to convey science meanings of the science content. Table 5.3.3.1 shows the everyday words in science context used by Thabo in his teaching.

Table 5.3.3.1 Summary of everyday words used in science teaching during Thabo's lessons

Everyday words in science		
Poles	Constant	Contact
Nature	Reflection	Normal
Properties	Media	Refraction

Of the above everyday words used by Thabo during her physical science lessons, I have selected five everyday words to show how these words were used in the context of the observed classroom lessons and whether these words were explicitly, implicitly or not interpreted according to context of use. Table 5.3.2.2 shows the five selected words and how the teacher used them in the physical science classroom.

Table 5.3.3.2 Contextual use of some everyday words in science teaching during Thabo's lessons

Mediation	EWS	Teacher excerpts
Non-mediation	Constant	…where it was asked, how a velocity can constantly increase ehhhhh how a velocity can be constant? *(recap from previous lesson)*
Explicit mediation Implicit mediation	Contact Normal	We have got other types of forces, like contact forces, what else? (S*ilence*) non-contact forces…we also have the normal forces which we said is the force that takes place between the surface of the objects. What is the difference between the non force and, I mean to say, what did I say? That type of a force. Contact force and non-contact force, what are the differences between the two? (Silence) contact force, what is a contact force? Who can help us? What is the meaning of the word contact? To contact…(after a long silence a learner responded but inaudible to be captured) To touch something hhhe yes you are right to touch something. If you touch something you are in contact with that particular thing.
Non-mediation	Nature	Today I want us to look at the nature of electromagnetic waves (teacher writing on the board). The nature of electromagnetic waves! Have you ever been in an empty hall? (learners: yes) Some have been there before neh, what happens when you say whoooahh!! (making some sound) in that room. (learners responding but inaudible). You get echoes, echo of your voice, the same thing will apply when you go into the mountain and you make the same sound, what will you hear? You will also hear the echoes neh.
Implicit mediation	Media	I am saying the difference between cold and as well as what? Cold and warm air, so the voice when it moves passing through a media called, … called cold air and when it move passes the warm air, will not sound the same, will not go just go straight… Generation of electromagnetic waves…but before we can go there we said sound waves are moving within a particular media so unlike sound waves, electromagnetic waves the ones that we were talking about here does not need any media to pass through. They don't need any media or rather any substance to pass through; they don't need any transport to move, right! So in other words electromagnetic waves can move in a vacuum where there is no media at all.

5.3.3.1 Thabo's usage of the word 'Constant'

When Thabo was recapping from the preceding lesson he used certain wording which included the use of the word 'constant' being used as follows: *"…where it was asked, how a velocity can constantly increase, how a velocity can be constant?."* Viewing from its everyday contextual

usage, the word ‘constant’ means something that happens all the times or something that happens repeatedly (Concise Oxford dictionary, 2011), while in Mathematical Literacy (school subject), the word ‘constant’ means to stay the same, something that does not change (Tenza et al., 2012). Contrastingly, in science the word ‘constant’ firstly refers to the values that have been scientifically experimented and been found that they remain the same in all conditions, for example, in Hooke’s law’s equation: $F=K\Delta L$, where K is the proportionality ‘constant’ (Giancoli, 2005). Secondly, ‘constant’ in physical science can also means the same rate (happening without changing), for example a car travelling at a ‘constant’ velocity (without changing) or the volume of gas being kept constant throughout the experiment. Moreover, from the observed lesson there was no mention or explicit explanation of what the word constant was referring to and this might have negative implications where learners could attach different meanings not that intended by the teacher.

During interviews, when I asked Thabo what is it specifically that he wanted his learners to understand about the velocity being constant. Thabo responded by saying that: “*The constant part of it, actually it is constant, scientifically it is uniform*”. To explain the meaning that the teacher wanted his learners to grasp, the teacher uses another everyday word in science context (uniform) without explicit explanation. Basically if the teacher were to give the above explanation of constant to his learners, of which he did not, he would also need to explain the meaning of the word uniform. However, when further probed on uniform, the teacher said the word uniform means: “*That it doesn’t increase, it doesn’t decrease it just move*”. Though the teacher has the basic understanding of uniform, his quality of understanding appears poor judging from his basic explanation of the meaning of uniform.

5.3.3.2 Thabo’s usage of the word ‘Media’

During his teaching, Thabo said the following:

> *Generation of electromagnetic waves…but before we can go there we said sound waves are moving within a particular media so unlike sound waves, electromagnetic waves the ones that we were talking about here does not need any media to pass through. They don’t need any media or rather any substance to pass through, they don’t need any transport to move, right! So in other words electromagnetic waves can move in a vacuum where there is no media at all.*

The phrase, ‘they don’t need any media or rather any substance to pass through, they don’t need any transport to move’ indicates that media was explained as the substance to pass through or the

transport in which electromagnetic waves move. The above word meanings were not made explicit to the learners. In the context of where media was used, the teacher seems to have been referring to medium (media in plural). This is because when asking the teacher what he was referring to he said: "*I was indicating that sound can pass through air, it moves through air, air becomes a media. Isn't waves can sometimes pass through water then water becomes a media"*. Of importance is the lack of differentiation of the media that learners might know from the context of media communication. Thabo's utterances in the interview suggests that he takes for granted the meaning of media as the main ways that large numbers of people receive information and entertainment of which it is mostly television, radio, newspapers and the internet (Stevenson & Waite, 2011). The lack of differentiation between science and everyday meanings of the word 'media' could cause a difficulty to learner's learning of the science content, if especially the everyday meaning of media is carried by learners to science classrooms. In addition, the teacher seems to assume that 'media' is only used in science hence no explicit mention of what the word means and then possibly differentiate or integrate with everyday meanings. It is this taken for grantedness of the functional value of everyday words used in science context that possibly adds to the 'difficulty' of physical science contents, and to the general poor performance of learners in physical science subject. Lastly, it is unclear how then learners can, in the assessment, talk about the idea of media and vacuum when differentiating the sound waves and the electromagnetic waves as per the teacher's explanation of this differentiation when given the lack of differentiation or integration of contextual meanings of media.

5.3.4 Simphiwe's use of everyday words in science

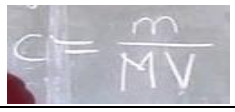
In her teaching of 'Atomic Mass and the Mole Concept' Simphiwe used everyday words in science context as shown in Table 5.3.4.1.

Table 5.3.4.1 Summary of everyday words used in science teaching during Simphiwe's lessons

Everyday words in science		
Quantities	Prepare	Solute
Solution	Unit	Amount
Constant	Theoretical	Subject
Products	Actual	

Of the above everyday words used by Simphiwe during her physical science lessons, I have selected five everyday words to show how these words were used in the context of the observed classroom lessons and whether these words were explicitly, implicitly and/not interpreted according to context of use (rephrase) and this is shown in Table 5.3.4.2

Table 5.3.4.2 *Contextual use of some everyday words in science teaching during Simphiwe's lessons*

Mediation	EWS	Teacher excerpts
Non-mediation	Solution	100g of sodium chloride is dissolved into 150cm3. How many moles of sodium chloride are present in solution? The last one, calculate the concentration of the solution. What is concentration?...what is concentration? We said is the amount of solute that dissolves in water. So the concentration would be, which formulas do we use? 
Non-mediation	Amount	Remember that when you have calculated the number of moles or when you have the amount of…you can calculate the quantities, the mass, you can calculate your molar mass your volume and your concentration. *Later on the teacher says,* the next example would be that example which says calculate the amount or mass of hydrogen required to completely react with 6... okay the question starts above lets start in the beginning then. If 6.4grams of oxygen reacts completely with hydrogen to form water, what mass of water is formed?
Implicit mediation	Theoretical	So what we are doing here is that in the industries when you produce a certain chemical, what happens is they use…we do have, we have a chemical equation that is followed and in that chemical equation, theoretically you can use stoichiometry to see that if I have this much of this product, this is the amount of the, I mean if I have this much of the reactants I am going to have this much of the products using the stoichiometric equations that we did. That is how we calculate it theoretically but we know ko re (that) you cannot actually produce 100 percent of that product in a reaction, a lot of things happen during the process of producing that chemical that is why we end up having percentage yield, calculating the percentage yield meaning the percentage that you are going to produce a certain

Implicit mediation	Actual	product. You compare the one that you calculated theoretically using stoichiometry to the one that you get when actually produce it in that industry when you produce in reality. The actual yield is the one that you are going to produce actually, like the one that you are producing in that industry you compare it with the one that you are going to….(teacher writing on the chalkboard quietly)
Non-mediation	Prepare	*[In the classwork activity, Simphiwe gave the following statement as the instructions to learners]*: 'A learner is required to prepare 200ml solution of potassium hydroxide (KOH) by dissolving 11,5g of the solute'.

5.3.4.1. Simphiwe's usage of the word 'Prepare'

In the classwork activity, Simphiwe gave the following statement as the instruction to learners, *'A learner is required to prepare 200ml solution of potassium hydroxide (KOH) by dissolving 11,5g of the solute'.* From this excerpt, Simphiwe did not explain the usage of the word 'prepare' and 'solution' to the learners but she read through the instructions as is. Lack of Simphiwe's interpretation of words seems to undermine the functional value of EWS in learning science and silently ignores that literature shows that contextual understanding of words such as prepare presents a difficulty to physical science learners (Oyoo & Semeon, 2015), even though it is not yet clear whether Simphiwe's learners would also encounter a difficulty with words such as 'prepare'. After probing Simphiwe about the lack of interpretation of prepare and whether she thinks learners will understand this word in the context of chemistry usage, she said: "*Preparing like making the solution, yah some of them will not understand when we talk about preparation or preparing…"* Interestingly is that the teacher acknowledges that some learners will not understand some words that are used in the instructions, nevertheless she never made explicit or implicit explanation of those words such as 'prepare'. Teacher's lack of explanation of EWS used in giving instructions could hinder some learners from understanding the teacher instructions and ultimately fail to respond to the question.

The lack of Simphiwe's interpretation of the word 'prepare' suggests that she overlooked the different contextual meanings of the word which might be brought into a physical science classroom. This is because, in its everyday use, the word 'prepare' means to make something or

somebody ready to be used or to do something. For example, a College that prepares students for career in business (Concise Oxford Dictionary, 2011). In science context, the word 'prepare' means to mix certain materials (chemicals) to produce a particular product.

5.3.4.2 Simphiwe's usage of the word 'Solution'

In one teaching episode, Simphiwe used the word 'solution' as follows:

> *100g of sodium chloride is dissolved into 150cm3. How many moles of sodium chloride are present in solution? The last one, calculate the concentration of the solution. What is concentration?...what is concentration? We said is the amount of solute that dissolves in water. So the concentration would be, which formulas do we use?*

The teacher wanted learners to calculate the moles of sodium chloride (NaCl) in a solution but she had only stated that NaCl is dissolved and there is no explicit reference to the formed solution after NaCl has been dissolved. Interestingly however is that instead of explaining the solution referred to in the instructions, the teacher explains the technical word 'concentration'. The technical word seemed to have appeared important than everyday words used in science for Simphiwe, and this could be possibly because of her orientations in physical science (philosophy), her understanding of teaching and learning physical science and or maybe the type of learners taught in the school's context.

In chemistry, a solution is defined as a mixture of substances that has a uniform composition; a homogeneous mixture (Brown, LeMay & Bursten, 2006). This definition is embedded in the teacher's talk during the interviews but seems to be absent in the actual teacher's classroom teaching, showing incongruence between teacher's talking about explanation of EWS and teaching practice in the classroom. When I asked the participant about the lack of interpretation for the word 'solution', and the possible difficulties that may be triggered by the use of the word solution, Simphiwe said:

> *…but then the part of the solution, when we did concentration I specifically said that we are talking about concentration of solutions …when we talk about a solution we talk about when a solute dissolves in a solvent that is a solution…so you see the solution part won't be a problem. Maybe the preparation part but I don't think, maybe ayyh (mixed emotions) some will some won't* [understand].

The teacher spoke about solutions in term one (first quarter of the year) of school calendar but still it remains unclear whether or not she explained the contextual meaning of this word when teaching in term one. Even though the teacher and I established that she used the word 'solution'

in term one but whether or not it was explained remains unclear. The teacher assumes the meaning of solution (solute dissolving in a solvent) to be a shared meaning between her and her learners. This assumption disregards the contextual meanings that learners may have based on how and where they have used the word 'prepare'. For example, mathematically solution refers to calculating and giving an answer from a mathematical problem, while in everyday talk, solution refers to a way of solving a problem or dealing with a difficult situation (Stevenson & Waite, 2011).

Finally, from the presented teacher's use of everyday words in science context, my findings suggests that participant teachers use everyday words in science context in various ways during teaching different topics within physical science subject. In their use of everyday words in science context, my findings further suggest that participant teachers were unconscious of the difficulties or role of the everyday words in science context during their teaching. This is apparent from the general lack of everyday words' interpretation by teachers, so more often EWS were left unattended as also alluded by (Oyoo, 2012; 2017).

5.4 Tension between general proficiency in "plain English" and science contextual proficiency in LOLTS

As mentioned in section 5.1, the third theme that emerged from classroom observation which was then followed up in semi-structured individual interviews was the *Tension between general proficiency in "plain English" and science contextual proficiency in LOLTS.* This theme addresses teacher practices regarding the use and understanding of English language (LOLT), use of mother tongue languages and its implications to science teaching and learning including that of EWS. Following is an analysis of classroom and interview episodes of teacher's language practices including explanations of EWS and consequently their implications in learning science language.

5.4.1. I code-switch, do you? The role of code switching in the mediation of SSMK including EWS

The emphasis on science language is motivated and influenced by the idea that language carries with it cultural leads and histories, and they shape how we think and understand the world (Gardiner, 2008). I draw, in particular, on the concept of code switching which is defined as the

practice where teachers use more than one language in the same conversation (Adler, 2001) with the purpose of explaining science concepts in science teaching. It assumes that a teacher can switch from the LOLT (English) to another language during teaching, due to various reasons which could include easy accessibility of content taught, and learners' poor proficiency with LOLT (English). Following is the analysis of each participant teacher's practice and perceptions on the use of English as LOLT, code switching and its implications for science understanding including that of EWS.

5.4.1.1. Thandi:

Thandi alluded that she uses English language as LOLT, she said "…*we no longer instruct with our mother tongue language…So we just trying to assist language teachers teaching in English*", and further said she is using a "*simplified English*", which according to my observations, the English did not seem to be simplified and it was not clear how Thandi's 'simplified English' helped learners in building science knowledge. Even though Thandi argued that she uses English as LOLT but she also code-switch to learners' languages (IsiPedi & Sepulana). The role of code switching is to emphasize as Thandi said: "*You need to emphasise* [through mother tongue] *but I think 95 coma something per cent of our talk, it will be English*". According to Thandi, the phrase "*you need to emphasize*" with mother tongue languages indicates that mother tongue languages play a role of emphasizing in science teaching and learning. Moreover, if 95 coma something per cent is English then the other more than 4 per cent classroom talk is through mother tongue languages. However, Thandi's observed practices did not seem to have utilized code switching for emphasizing on science concepts including EWS, but was used mostly to motivate, to give instructions, for classroom management, and interpersonal relations.

Even though Thandi argued that she uses mother tongue languages to emphasize she also thinks that the use of English helps learners to understand science better. Thandi said:

> *Mhhhhh! I think it helps the learner because when they further their studies, like doctors and other stuff, you find that the phrases are just like that. Then to eliminate frustrations…do most of the work in English. Although there and there we emphasise when we see that they are stuck. Then mother tongue so that you simplify the concepts.*

The phrase "*we emphasise when we see that they are stuck"* indicates that learners not necessarily have the required general proficiency in LOLT (English) and unable to understand science text through the medium of English, and could also mean that learners are impotent to

comprehend science language through English medium. Moreover, Thandi indicated that science words are just science words but later on during the interview mentioned that she uses mother tongue to "*simplify the concepts*". There seems to be a contradiction in Thandi's talk because it is not clear whether mother tongue simplifies science content or English language, and how then mother tongue helps learners to access science knowledge effectively if science words are just science words. From the interview, it appears that Thandi's learners have difficulties with the use of English as LOLT because she gave one example of a learner who was asked a question in class and Thandi stated that the learner:

> *…understood what I want and he know the function of copper but he can't say it in English because I just let him… ehhhhhm a re ko mohlagase (and he says it's electricity), mohlagase is electricity*

Given this teacher insight on LOLT difficulty and also based on the observed lessons, Thandi did not explicitly explain the normal 'plain' English words when used in science classrooms (including EWS), even though she is aware that her learners have difficulties with English language in science. Possibly because according to her learners might have had difficulties but were not yet 'stuck' as she mentioned that she eliminate English frustrations when she sees that learners "are stuck" then use mother tongue to simplify the concepts taught.

5.4.1.2. Ayanda:

In another interview episode with Ayanda, she argued that she uses strictly English language when teaching physical science, but with the room for mother tongue language especially for disciplining learners. Ayanda said:

> *Myself I use English. I use English because… teaching in the Xitsonga I don't want to lie I don't normally do it unless I am just disciplining learners in general…*

However, teacher's strict use of English does not seem to lessen English language difficulties encountered by her learners and to address those language challenges during teaching Ayanda argued that:

> *What I normally do is, I ask amongst the learners, I know some got it, if he has or she has understood the concept then I asks her or him to explain in their mother language to the other learners.*

This language-based teaching strategy seems to suggest that use of mother tongue languages by learners-to-learners (peer teaching), increases learner understanding of science knowledge as

also argued by Dlodlo (1999). Important to note is the reason Ayanda allows her learners to use mother tongue to explain science ideas to their peers and this is because "*their* [learners] *English is very bad. It is very bad*". The challenge with Ayanda's learners seems to be the poor general English proficiency which, to some extent, shows the influence of LOLT in teaching and learning science that LOLT also acts as a barrier for rural learners to understand science. If learners 'English is very bad' it is equally worrying how these learners read, interpret, analyse and answer science text during their physical science examinations which is written through English language.

From Ayanda's classroom observations, she used minimal code switching as I can only re call where Ayanda said: *"You start by asking yourself, what kind of elements are these, are they metallic or non-metallic? (learners: non-metallic) They are non-metallic akere (isn't it)."* In another teaching episode, Ayanda said *"Now yes you have a question yes (*pointing at a learner*)"* and the learner asked a question in Xitsonga language about the separation of salt and water in a low voice and could not be captured for transcription. Of importance however is that the teacher understood the learner's question and then responded in English by saying:

> *This water doesn't have salt at all or … (learners laughing and booing the teacher) right okay okay let me elaborate the process again before I come back to what you are saying*

5.4.1.3. Thabo:

Likewise, to emphasize and/or enhance the process of science teaching and learning, Thabo stated that **"***Sometimes I code-switch to Sepedi* [learners home language] *not for a long time just to emphasize some of the points, where I realize learners are having difficulties with a particular concept*". In line with Thandi's idea of simplifying the concepts through mother tongue, Thabo also uses mother tongue to "…*emphasize some of the points*" more especially where "...*learners are having difficulties with a particular concept*". However, it did not come out clearly from the observed lessons how the teacher actually goes about helping to emphasize through using learners' mother tongue languages and how this ultimately enhances the understanding of physical science content knowledge.

Another practice that I observed with Thabo was his use of code switching but whenever code switching was used the teacher would go to the specific groups and emphasize on the

instructions especially for the magnetic field demonstrations. So it was difficult for the video recorder to capture the actual wording that the teacher used during code switching practices.

5.4.1.4. Simphiwe:

In teaching physical science, Simphiwe stated that "*I use English but sometimes I explain in their home language at times just for them to make…to get to understand whatever we are talking about*". The phrase "*sometimes I explain in their home language*" indicates that code switching is practiced by Simphiwe. Moreover, the phrase "*for them…to understand whatever we are talking about*" suggests that learners sometimes do not understand through the use of English as LOLT (poor proficiency in English) hence a need according to Simphiwe to use learner's home language. Given this poor proficiency in English as LOLT, the teacher has a responsibility to teach the language (English and STL including EWS) so that she can teach science effectively according to Seah and Yore (2017). In contrast to helping learners understand through the use of mother tongue, Simphiwe argued that in "…*using their* [learners] *home language it does not help much*", meaning the use of mother tongue is limited in science classrooms.

Denoting that mother tongue might be assisting learners to learn science but there is an extra efforts to be taken in order to move towards science contextual language users as Simphiwe alluded that "…*if you doing science you are doing the language* [Science language which needs proficiency in English] *and the maths at the same time"*. Then code switching might be putting triple task on learners, to master and use their mother tongue languages in science, then once science knowledge is comprehended then they have to convert such information into English as LOLT and then lastly taking it from plain English into science contextual language before science knowledge is fully internalized. As a result learners needs to be competent in the language used to teach and learn physical science and that language of school science "…*is not the general language that we use* [Not 'plain' English], *so they need to get used to that* [STL], *all those terms, they need to get used to it*" Simphiwe said. This statement shows the importance of science teachers' language and Simphiwe's awareness of language issues, even though Simphiwe values/refer more to technical words rather than non-technical words including EWS from her statement.

Additionally, Simphiwe also noted learner difficulties with the use of English (LOLT) saying that "*Getting to understand what question actually means*" is one of the difficulties encountered by her learners. Of importance is that Sipmhiwe links poor proficiency in the LOLT (English) to the rural context of the school (school's surrounding environment). Simphiwe said:

> *But the language barrier is a serious challenge in this context* [rural context], *remember physical science each and every question must have a scenario…, so in physical science you have to get used to the words that they use in questioning, get used to the whole scenario…So a lot of learners cannot understand that*.

In brief, this study's findings suggest that rural Acornhoek physical science teachers practice code switching for various reasons including issues with rural context of the school, learner proficiency in English, classroom management, and code switching also embedded in teacher's teaching approaches. Of importance is that code switching in science teaching is practiced regardless of the idea that "*science language differs with English language*" as Thabo indicated during interviews and irrespective of the view that "…*greater percentage of science words are just science words*" as stated by Thandi, meaning science is unique and not necessary a matter of English even though one needs a general proficiency in the language used to teach and learn science. Given for example, the greater percentage of science words being just science words, it is not clear what role does mother tongue plays in the teaching and learning of science words including EWS.

Moreover, all four participant teachers acknowledged that English is their LOLT and also argued that learners' general proficiency in English is the challenge which hinders effective understanding of science without a need to code-switch to learners' home languages. Furthermore, instead of improving learner general proficiency in English, teachers encourage code switching regardless of the idea that attaining general proficiency in LOLT is a necessary first step in effective comprehension of EWS (Oyoo & Semeon, 2015). Moreover, the lack of teacher's specific attention to LOLT, even the code switching is taking specific attention to the difficulty of LOLT and LOLTS, and consequently science language including EWS undermines the view that learning science means learning science language and mathematics (Childs et al., 2015).

5.5 "Nobody has to teach something invaluable"

The fourth theme *"Nobody has to teach something invaluable"* address teachers' perceptions of the importance of understanding everyday words contextualized into science text; and the role of science contextual language including EWS[34] use in physical sciences lessons. In order to understand teacher perceptions of the everyday words when used in science context, teachers were asked about the value and importance of explicitly explaining particular EWS as encountered during the observed lessons. Thandi thinks there is value in using science specific language when teaching physical science, she addressed the complexity of language in her school, which seems to influence her teaching of science:

> *I'm thinking it* [value] *is there because I …* [thinking] *here they are just talking Sepedi, they are writing Sepedi but they are talking Sepulana[35], the language which they are talking is not the language which they are writing, that's where there is a confusion*

The expression "*the language which they are talking is not the language which they are writing"* indicates that even though teachers might attach value in science specific language it could be influenced by the language spoken and written by learners and then LOLT (English). With the 'value of science specific language' in mind, the rural context present its own challenges that need to be considered when thinking of the value of using science specific language and this can be seen when Thandi explained the language dynamics of her school context and then saying "*…that's where there is a confusion"* in language spoken and language written and LOLT (English). Thandi suggests there is value in using science specific language when teaching physical science, but appears to have confused science specific language with the use of code switching.

While it appears like the participant confuses value in science specific language and learner home language, it is possible that she recognizes the value of using science specific language but the challenge in her context is the complexity of the language learners use for talking and writing

[34] It is important to mention that the participant teacher did not share the same definition of everyday words when used in science context (EWS) with that of the researcher because the researcher did not explicitly explain the definition of EWS to the participant teachers.

[35] Sepulana is a language spoken mostly by Mapulana who occupy the area known as Mapulaneng, this language forms part of Northern Sotho and is classified as a dialect of Sepedi. Sepulana is not within the 11 South African official languages but is still used in South Africa.

making it complex of which everyday language to use as the basis for EWS. This appears to address the unconsciousness in explaining EWS when considering that she used EWS while teaching but overlooked the significance of explaining the multi-contextuality of these words which further reflects the taken for grantedness of the functional value of EWS. Furthermore, I asked Thandi if it was important to explicitly explain some of the everyday words (eg. Phases, held, reactions) used during her physical science lessons. Thandi believes it is important to explain the meanings of EWS:

> *I think it is important. I think it is important because when we just say phases of matter, learners can just give you other solids, other tangible things forgetting about water*

Although the teacher mentioned the importance of explicitly explaining EWS when encountered during science teaching, but she does not seem to know much about EWS or their importance and this can be seen from the above teacher response.

On another hand, Ayanda advocated for learner self-study through science textbooks to improve learner proficiency in the language used in science classrooms. Ayanda further suggested that she sees importance in learning science language even though she does not indicate that she mediates science language but recommending textbooks to be used by learners individually outside classroom. Of importance, Ayanda acknowledged that learners do not study their textbook even though she suggested the importance of reading more textbooks, with the assumption that they will develop science contextual proficiency as they read more. Ayanda's utterances illustrate this:

> *Ehheh they should know the difference* [between science and everyday meanings of EWS]. *When you study, even still when you study, somehow you develop along those lines, but if you don't study, and then you can't know*

The teacher perceives EWS as words that can be self-learned by the learners by suggesting that the more learners study science textbooks in general, the more they are likely to be competent in the physical science contextual languaging. The teacher seems to leave unnoticed the role played by teacher's explanation in mediating science contextual language during her teacher talk because the textbook does not give both meanings (everyday and science) of the EWS used. Ayanda's recommendation of the textbook raises a question: does really knowing the difference between everyday and science meanings of EWS depends on learners reading the textbooks? In addition to the perceived explanations of EWS in the textbook, Ayanda also alluded that if she

explains meanings of EWS she does not get into details of such explanation, meaning that even though she explains EWS but she does not see any value in explaining in details the "just" special words of science teachers' language. Ayanda said:

> *Myself I… (*pause) *but when I explain it to learners of course* ***you don't get deeper****. Why are we saying it's a noble,* ***it's just a special name****, according to the grade 10 concepts they are saying they are basic groups of elements which have got special names. Like group one, two…seven, alkali metals, halogens, and noble gases.*

The pause on the phrase "Myself I… (pause) but" suggests that the teacher might have changed her mind after thinking through the use of "but". While it is unclear what the participant mean by "…when I explain … you don't get deeper" it links with the above response that promotes the reading of textbook, which suggest that Ayanda does not attach importance in the explanation of contextual meanings of EWS which undermines the value of EWS in science teaching and learning science. Ayanda alluded that she does not *'get deeper'* when referring to EWS even though from her observed classroom teaching, there were few explanations of the EWS (including participate, structure) and these words were not explained in detail, she did not "get deeper" as she indicated. Moreover, not getting deeper in explaining EWS could contribute to the teacher unawareness of the possible difficulties encountered by learners with EWS. Furthermore, it could mean it was deliberate or intentional but as presented, it suggests that the participant does not attach any value in EWS and EWS's explanation during science teaching. In addition, the phrase "…*noble, it's just a special name"* suggests that Ayanda approaches EWS from their science context of use only and forgetting the possible familiarity of the word 'noble' to learners outside science registers and/or outside school context. Referring to noble as being just a special name could mean that Ayanda was not aware of the meaning of 'noble'.

When Ayanda was further probed whether it is important to explain the contextual meaning of EWS such as 'noble' she responded by saying *"to me, I think it depends with the scope of Grade 10".* As much as Ayanda seems to be guided by the Grade 10 curriculum not to look at language needs of her learners and it is surprising that Ayanda says this when the Grade 10 physical science curriculum explicitly state that "It is important to provide learners with opportunities to develop and improve their language skills in the context of learning Physical Sciences" (DBE, 2011, p.14). Irrespective of the scope of Grade 10, Ayanda does not seem to attach any importance to the EWS or their explicit or implicit interpretation during physical science teaching and this was also evident in her lessons that I observed. Moreover, Ayanda presented

mixed views on whether she explains the meanings of EWS such as 'noble', she argued that she explains when learners have specifically asked about them and she said "*But if they ask then I'll explain to them…but if maybe there are those learners who would want to know but you can't know them".*

The phrase "*there are those learners who would want to know but you can't know them*" suggests the importance of explanation of EWS, given that it is Grade 10 that introduces and also continues from previous grades knowledge about science. Teachers cannot take for granted that learners understand, but should explain content/words' meanings to them. Ayanda suggests that EWS should be explained when learners have asked these words. Ayanda through laughter added that above saying: "*…nobody has to teach something that is not valuable".* This statement suggests that Ayanda views EWS as invaluable in teaching and learning physical science regardless of the functional value and the importance of EWS in serving as conveyor belts of meanings.

Besides the first two participant teachers, Simphiwe seems to have initially perceived EWS as invaluable but changed her perception after probing and through practical scenarios where she had used EWS in her classroom teaching as shown in the following discussion. Simphiwe used the word 'prepare' (without explaining it to the learners) in giving instructions which was to lead to mathematical calculations, and Simphiwe said:

> *So now when you talking about concentration of a solution we are actually talking about the amount of that solute which will dissolve in that solvent to form that solution, so you see the solution part won't be a problem. Maybe the preparation part but I don't think, maybe ayyh* [mixed emotions] *some will, some won't*

The phrase "*solution part won't be a problem"* indicates teacher assumptions of the shared meanings of the word 'solution', because during in her observed lessons she did not attempt or explain the meaning of 'solution'. Of importance however is that the teacher seems not to have given special attention to whether learners specifically understands every wording like 'solution' and 'prepare' as used in the science text. Moreover, the teacher took for granted the word 'prepare' and she alluded that some learners will understand it and some will not understand but still to her it is not a problem that some learners would not be able to understand the key word 'prepare' in the teacher instructions. According to Simphiwe, whether or not EWS are explained to learners does not really makes any difference, because some will understand and some will not

understand. Some learners will always not understand as Simphiwe suggested, her impression is that she does not see a point in explaining EWS such as prepare (preparation).

When Simphiwe was further probed about differentiation in explicit explanation of EWS, she later on realized the importance of EWS and the importance of EWS's explicit explanation, where she said:

> *explained neh yah there you are right, there you are right* [silence]…i*t is important. Ehhhm maybe I will do, I will explain to them tomorrow again when I do the corrections*

Simphiwe now sees a need to explain some of the EWS used in her lessons but this paradigm shift in thinking only came after I had probed showing her some importance in the explanation of the EWS. This shift in thinking can also be noted where Simphiwe said explaining the meanings of 'theoretical' and 'actual' which were used during the teaching of percentage yield in Simphiwe's lesson. The phrase "I will explain to them tomorrow" could be the teacher's teaching strategy, allowing learners to find out about these words before she explains them or it could suggests that she was not explaining the EWS like 'actual' and 'theoretical' from the previous lessons until the interview. It appears that the teacher has now attached some importance or sees a value on explaining meanings of EWS like 'theoretical' and 'actual'. Initially Simphiwe took for granted the functional value of EWS but changed her perception of EWS after the interview session where she further said:

> *… I did not actually think that they cannot know, ok like what actually does the word yield means in general language and how can we apply in science, the theoretical part and the actual part. So you see that we learn everyday and in order to grow you have to be learning so if you are not learning anything you are not growing*

Simphiwe's phrase *"I did not actually think that they cannot know"* questions the teacher's assumptions that learners know the meaning of solution in science context. This phrase further shows teacher ignorance or unawareness of contextual meanings of EWS and the difficulties posed by EWS due to their polysemous nature. However, the teacher noted that EWS can be equally applied in everyday talk but of importance in science is "*how can we apply in science*" as stated by Simphiwe.

Likewise, Thabo thought that it is important to explicitly explain the meanings of EWS to his learners even though there were few instances where he attempted or explained EWS in his observed teaching practice. The disparity from interview content and teacher's actual classroom

teaching suggests incongruence of what Thabo says he does and what he actually do in practice, more especially in relation to the explanation of EWS. The incongruence could be a result of a teacher's history and cultural backgrounds, including teacher experiences accumulated from physical science teaching, teacher training programmes. Thabo attaches the importance of explicit explanation of EWS such as 'constant' as he stated that:

> *yeah it is important... they will be able to understand that ehhhh when objects are moving its either they accelerates or decelerate or they move with the same speed. As they move with the same speed then it is where we are saying its constant*

The attached importance is linked more with knowing science facts like the phrase *"when objects are moving its either they accelerates or decelerate or they move with the same speed"* so in explaining the EWS (constant) Thabo used technical words (accelerate, decelerate, speed) which might need further explanation to learners.

Additionally, Thabo also assumes that meanings of EWS should be explained because learners meet some EWS such as 'media' for the first time, maybe in grade 10 physical science yes even though 'media' is well spoken of in the everyday conversations. This is where Thabo said: *"you are right, because ehhhm as they are still from grade nine and they meet those terms as new terms to them then its important to actually highlight those things".* Even though assuming that learners were seeing and/or hearing 'media' for the first time that would have necessitated the explicit explanation of what the teacher was referring to in the science context but did not explain the EWS. In addition, Thabo's statement raises questions of whether he could have explained the word 'media' if learners were not meeting it for the first time and why he assumes that they are meeting this word for the first time or it is because it is the first time he was talking about it in this lesson. Thabo has informed judgement of learners in relation to the used word, media.

It is important to explain contextual meanings of EWS including those that have become familiar in the physical science school register but effective explanations of EWS is to some extent influenced by teachers perceptions towards EWS; teaching physical science; teaching context.

5.6 Chapter summary

From the poor state of physical science learning in South Africa as indicated by Grade 12 physical science performance, it is important to gain insight into teachers' teaching practices and

their perceptions towards teaching including EWS. This chapter presented the findings of the study by categorizing and highlighting the findings into four themes that emerged from the findings of the study. From the classroom observation and interviews, I found that greater percentage of classroom talk was teacher talk. In their talk, teachers explicitly explained technical words with avoidance or lack of explanation of EWS, in instances where EWS were explained, they were mostly implicitly explained. Additionally, most teachers perceive EWS as not being valuable, as not deserving deeper explanation, while some teachers perceive EWS as being important for the holistic understanding of SSMK and deserving explicit explanation during teaching. The findings also shows that rural Acornhoek physical science teachers were not aware of the learners' difficulties instigated by the use of EWS and more disturbingly is that some teachers also lack knowledge of the contextual meanings of EWS. Most importantly was that teachers' language practices was i*nfluenced by the rural contextual social realities, teacher knowledge of SSMK and EWS, teacher experiential (personal & training experiences), situational (classroom organisation, resources), nature of teaching physical science, beliefs about language in teaching and learning science*, syllabus completion, context of learners and their general proficiency with LOLT, teacher beliefs about teaching physical science, teacher's motivation; their personality; attitudes, interests, expectations; and the influence of their science cultural background.

CHAPTER 6

RE-IMAGINING EWS IN PHYSICAL SCIENCE TEACHING: ANALYSIS OF FINDINGS AND CONCLUSION

6.1 Introduction

The overarching purpose of this study was to critically explore and cross-examine rural Acornhoek physical science teachers' use of EWS within Grade 10 science classrooms. Additionally the study sought to unearth teacher perceptions of EWS and the factors that contribute to teachers' perceptions and usage of EWS in science classrooms. The study was designed to engage with the following main research question: *How do Grade 10 rural physical science teachers use everyday words during physical science lessons?* To help answer the main research question, the following sub-questions were asked:

a) What are Grade 10 rural physical science teachers' perceptions of using everyday words in science classrooms?
b) To what extents are rural physical science teacher's aware of the difficulties of everyday words when used while teaching science?
c) What are the factors that shape rural physical science teachers' perceptions and the usage of specific everyday words when used in science classroom context?

As discussed in chapter 3, the Vygotsky's (1978) concept of mediation helped to understand the mental processes and activities primarily at the social level, by conversing with teachers (interview) and observing their teaching practice as they mediate science knowledge. On the other hand, Scott et al.'s (2011) concept of PLM assisted in examining the links made by teachers between the everyday ways of explaining and the scientific ways of explaining, with the focus on teacher's approaches, whether and how they integrate and/or differentiate between everyday and scientific meanings of EWS with also the principle of social language of science in mind. With the consolidation of mediation and PLM, this study considered the complexity of the contexts within which teachers used the target science language, and specifically the everyday words used in the physical science lessons. With that borne in mind, PLM was used to analyse

the data collected through classroom observations, while the data collected through interviews was analysed with qualitative content analysis and the principles of social language of science. Of importance, however, is that classroom observation and interview data were not analysed in isolation but were integrated as they were all about mediation of everyday words when used in science classroom context. This chapter presents summary of the study's findings and giving directions to the future research in relation to the findings of the current study. The chapter begins with the summary of the findings of this study, followed by recommendations and then limitations of the study.

6.2. Physical science teachers' perceptions and the usage of everyday words in science classroom context

This study found that some teachers perceived everyday words used in science context as invaluable in science lessons because some words are special to science and there is no need to explain them, which means they are self-explanatory. Some participants viewed everyday words in science lessons as important because these words help learners understand science. Moreover, participants did not explained most of the EWS used during their teaching of various topics in physical science and this lack of explanation could have led to unintended meanings of EWS to the learners or by science context. It appears like participants assumed shared meanings of EWS between the teacher and the learners and this led to teachers not explicitly explaining the all EWS that they use during teaching.

6.2.1. Teachers' approaches in using EWS during physical science teaching

Teachers' usage of EWS was highly influenced by how teachers approached physical science teaching in general through using QATA, demonstrations during teaching. This included mode of communication by teachers which were mostly interactive/authoritative communicative approaches, which means participant teachers used mostly rote learning during physical science teaching. The participants' mode of communication were preferred teaching approach(es) which might have been influenced by the teacher's knowledge of SSMK and EWS, teacher experiential (both personal experiences and training experiences), situational (classroom organisation, resources), nature of teaching physical science, beliefs about language in teaching and learning science

Moreover, irrespective of being trained in a particular context (university or college), Question and Answer Teaching Approach (QATA) appeared dominant in all four participants. The reasons for this dominance were the lack of resources (visual representations), teacher's preference in approaching science, and understanding of learner's background. Through the use of QATA in certain lessons like those of Simphiwe, Thabo and Ayanda especially, questions were phrased to capture learner's attention on important points, arousing their curiosity as also argued by Al-Darwish (2012).

Another observed teaching approach towards EWS was analogical link-making where Thandi and Thabo were helping learners towards an understanding of a scientific target concept by making an analogy with a familiar case and Scott et al. (2011) see this way of teaching as being "…likely to be helpful in supporting learning" (p. 12). From the observed lessons, the classrooms discourse was largely monologic, meaning that teachers were more concerned about maintaining control of the classroom, learners, and content taught. Of importance however is the observation from the findings that most of the classroom talks were teacher talk. Nonetheless, for a developed conceptual knowledge, learners need to learn the language of science, which requires practice not just listening to the teacher (Haug & Odegaard, 2014).

To support physical science teaching, some teachers did not seem to use other materials to enhance the teaching and learning of physical science except the textbook, while the other three participants used visuals (practical work/demonstrations) for one lesson each during my presence in the schools. Even though visuals (practical work / demonstrations) were used, the teacher was the main role player with learners sitting quietly observing the teacher and the teachers talk dominated these teaching episodes. The rote-learning encouraged by at least.

6.2.2. Explanation of EWS during physical science teaching

More often technical words were explicitly explained with avoidance or lack of EWS explanation, because teachers emphasized more on the key words of science (technical words). When EWS were explained, they were mostly implicitly explained. The most experienced teachers used analogies from learners' immediate environment to communicate both technical and non-technical word meanings, including EWS but such meanings were not made explicit to learners. Moreover, participants with least teaching experience (Ayanda and Simphiwe) tended

to teach abstractly with least explanation of meanings of EWS while participants with most teaching experience operated mostly on learners' levels (use of analogies, hands-on tasks) even though not many explanations of EWS were observed.

Most everyday words used in science were not explained from the observed lessons, which could explain why science learners might understand the word meanings that were not necessarily intended by the teacher or by the science text. From most of the observed lessons there was no explicit word (EWS) meaning differentiation from everyday context to science context (Oyoo, 2012). Observed mostly in Thabo's lessons were efforts to use learners' prior knowledge including everyday meanings of words, leading learners to science context understanding. Participants' teaching practice did not appears to compliment teachers beliefs about science language being different from the 'plain English' as little explicit differentiation was made between everyday English meanings and science contextual meanings of EWS.

Participants' teaching approaches did not include initiation of learners into the science discourse but were just teaching textbook physical science with little or no attention paid to the language of talking science, the science contextual language regardless of the idea that learning science is learning how to talk science (science contextual language) (Lemke, 1990). Hodson (2009) noted learners fail to understand that "sometimes the precise meaning of a word is only apparent in its context of use" (p.245) in a sense that everyday meanings of EWS can interfere with scientific ones. Though Hodson (2009) noted this on learners, my findings also suggests that science teachers also takes for granted that EWS have contextual meanings and if not mentioned explicitly can influence understanding of science meanings. Lastly, during interviews participants expressed the importance of science language and its explanation but from the observed lessons teachers did not pay attention to science contextual language needs. This contrast in classroom teacher's practice and teacher's expressed intend during the interviews suggest that teachers do not know how to help their learners to understand the language of school science including EWS (Christie, 1989).

6.2.3. Teachers' perceptions of EWS

Some participants advocated more on the learner self-study through science textbooks to improve learner general proficiency in the language used in science classrooms, suggesting that

they see importance in learning science language even though they did not indicate that they mediate science language but recommended science textbooks to substitute their role in being the mediators of knowledge. When asked about the role of EWS and its explanation during teaching, participants responded saying that: "*Myself I…* [Thinking] *but when I explain it to learners of course you don't get deeper",* "s*o we just teach them according to the textbook"* and "…*nobody has to teach something that is not valuable*". Showing that participants attached little or no importance of EWS in science teaching and learning (Oyoo, 2017). For example, when asking Ayanda whether it is important to explain the contextual meaning of EWS such as 'noble' (EWS used in her classroom teaching) she responded by saying *"to me, I think it depends with the scope of Grade 10".* This was said regardless of the of the curriculum's need for physical science to be language teachers by improving learners' language skills within the context of physical science subject (DBE, 2011).

6.3. Teachers' awareness of the difficulties instigated by the use of everyday words in science context in learners' learning of science

The findings suggest that teachers never expected learners to encounter difficulties with EWS, hence they never took time to explain during teaching the contextual meanings of used EWS. Teachers' lack of knowledge regarding EWS and its difficulties it poses to physical science learners is worrying because as teachers we are anticipated to be "someone who has acquired some knowledge, skills, attitudes, ideas or appreciation in order to create or influence desirable changes in behaviours of his students" (Okoro, 2011, p. 107). Instead of showing some desired teacher qualities, teachers were observed not to have explained EWS during teaching, probably due to their unawareness of EWS and their functional value in teaching and learning science.

What is emerging from findings of this study is that teacher unawareness of the difficulties with EWS is interconnected with teacher knowledge of the meanings of EWS. Teachers unawareness of the difficulty with EWS takes for granted learners' unfamiliarity with the usage and meanings of everyday words in physical science context. Some participants mentioned unawareness of learners' lacking science contextual meanings of EWS used during teaching, which means they overlooked the functional value of EWS, the contextual meanings of EWS and the difficulty presented by the use of EWS. During teacher interviews, the participant teachers largely associated difficulties with teaching and learning physical science to learner poor proficiency in

English language as LOLT; learner difficulties in understanding science concepts (difficulty of the subject); lack of learner discipline (poor self-study); and lack of chemicals (materials) for science practical work but did not refer to contextual understanding of EWS.

6.4. Factors that shape rural physical science teachers' perceptions and the usage of everyday words and their awareness/unawareness of difficulties with EWS

Part of the findings of this study suggests that teachers' pedagogical approaches in physical science classrooms' are mostly associated with school's rural context (social context), teacher's personal experiences and training. Specifically, explanation or lack of explanation of EWS seemed to be influenced by various factors including syllabus completion, teacher content knowledge, context of learners and their general proficiency with LOLT, teacher beliefs about teaching physical science. One of the factors to have contributed to the lack of explicit focus on language practice including EWS was teacher's uneasiness with science content knowledge. Some teachers at times seemed to struggle with content as they often gave incorrect spellings of science terms (See Appendix 8, where for example 'mater' was written instead of 'matter', 'model' being written as 'moldel', and magnesium written as 'magnecium'), use of code switching more often not to simplify or emphasize on science knowledge but to talk about off topic issues. These observed practices may have been also influenced by the researcher's presence in the teacher's teaching spaces leading to teacher nervousness. On the other hand some participants appeared to possess science knowledge higher than that of high school level learners and to guide their content they resorted to reading from the textbook. These participants' content knowledge suggested that it was influenced by their qualifications (Bachelor of Science (BSc)/Chemistry) eventually shaping their teaching approaches. Teachers' practices of reading from the textbook seemed to have hindered the effective explanation of terms including EWS and reading from textbook without much explanation seems to disregard that science concepts become too abstract and impersonal (Lemke, 1990). In addition, it could be that teachers were reading from the textbook because they were also under pressure of finishing the Grade 10 syllabus as learners were about to write end term tests during the time of research data collection, as Simphiwe also mentioned that at Grade 10 level they are doing a lot of work unlike Grade 9.

Another contributory factor on teacher's lack of focus to language practice was lack of learner engagements in class because more often learners were engaged when having to answer teacher's questions but most of the time learners were like passengers in their classrooms. Participants did not encourage discussions or giving learners opportunity to verbalize their thoughts but teachers were leading learners to one point of view using what Scott et al. (2011) call Interactive/authoritative approach. Such practice of silencing learners made learners to go out of class without their pre-instructional or prior knowledge being known by the teacher, because of assumptions that EWS are 'plain English', common and simple words to learners.

The findings of this study also suggest that teacher's perceptions to EWS and their teaching approaches were mostly associated with school's rural context (social context), situational (classroom organisation, resources), learners' abilities to comprehend science knowledge, teacher beliefs of science teaching including EWS and their experiences (personal and training). The situational environment refers to lack of science laboratory, classroom organization (overcrowded classrooms), and where it exists poor / unmanaged or lack of libraries, which then positions the teacher at the core of teaching being the main source of knowledge including knowledge about contextual meanings of EWS. Moreover, participants revealed that training experiences plays a role in their teaching approaches to science including EWS, meaning their teacher education did not prepare them to be language teachers of physical science. For example, Thandi alluded that her training experience was poor and linked that to her teaching approaches. The findings of this study also indicate that teacher beliefs and perceptions of science teaching including EWS could affects negatively or positively teacher's teaching of science content including EWS.

6.5. Re-imagining the role of EWS: Summary of findings

Participants used dominantly interactive/authoritative communicative approaches (Scott et al., 2011) in approaching physical science teaching in general and this approach was influenced by various factors within science classrooms, within school contexts and other factors outside school context. Another observed teaching approach used by participants was analogical link-making (Scott et al., 2011). To support teaching, textbook was highly utilized by all participants as the main source of science knowledge even though practical work/demonstrations were also done by some participants.

More often participants explained technical words over non-technical words (EWS). Some participants explained EWS (explicitly & implicitly) even though the amount and quality of explanations of EWS was unfavorable. In most cases EWS were explained implicitly during teacher talk. However, most of EWS used by all participants were not explained. Lack of EWS explanation, for example of the following EWS is regardless of the literature which positions these EWS as requiring special attention, EWS such as *composition, random, transform, uniform, conserve* (Tao, 1994), *theoretical, reaction* (Oyoo, 2012) and *prepare* (Oyoo & Semeon, 2015). Participants' lack of initiating learners into talking science proves to be disadvantageous to learners' overall understanding of science.

Findings of this study revealed that participants never expected learners to encounter difficulties with EWS hence they did not take time to explain the contextual meanings of EWS during teaching. Interestingly however, everyday words used in science context have been noted widely that they present problems in learners' learning of science, yet teacher's remains unaware of this difficulty. From the findings of this study, I have identified the dominancy of English perspective on everyday words used in science over science perspective; unawareness of the functional value of everyday words used in science teaching and learning; teachers' experiences with teaching and learning of physical science as some of the contributory factors to teachers' unawareness of the difficulty posed by the everyday words used in science context. While some teachers, after probing, seems to be aware of the difficulties posed by everyday words used in science classrooms, it is surprising that explicit explanation of these words was silent in the observed teacher's classroom teachings. Some teachers who did show some level awareness of the difficulty posed by EWS. However, these teachers still had limited available teaching strategies in dealing with EWS during physical science teaching and for assessment purposes, it is mostly the telling of science meaning without integrating or differentiating with everyday word's meanings.

Most of the participants initially perceived EWS and EWS explicit mediation negatively or considered it as not important. As such teachers do not target everyday words used in science context (EWS) or provide multiple exposure to science terms and they do not seem to make connections between 'spontaneous' and 'scientific' words (Vygotsky, 1978; Bravo et al., 2006). However, two of the four participants changed their perceptions after discussions from in-depth

interviews. Participants alluded that they work according to Grade 10 scope, which according to participants does not require them to explain EWS but when they do explain they do not get deeper with such explanations showing that teachers do not attach value or pay much attention to EWS. Participants' perceptions, their usage of EWS and their awareness/unawareness of difficulties with EWS are influenced by variety of contextual, experiential and personal factors. These factors could contribute in leading to successfully constraining and/or enhancing learners' learning of physical science content given that learning science is learning to talk science (Lemke, 1990).

I have summarized and presented diagrammatically the findings of this study (Figure 6.1 on the subsequent page). Figure 6.1 shows the factors influencing teacher perceptions' and their usage of EWS which ultimately could (could not) constrain learners' learning of science content knowledge.

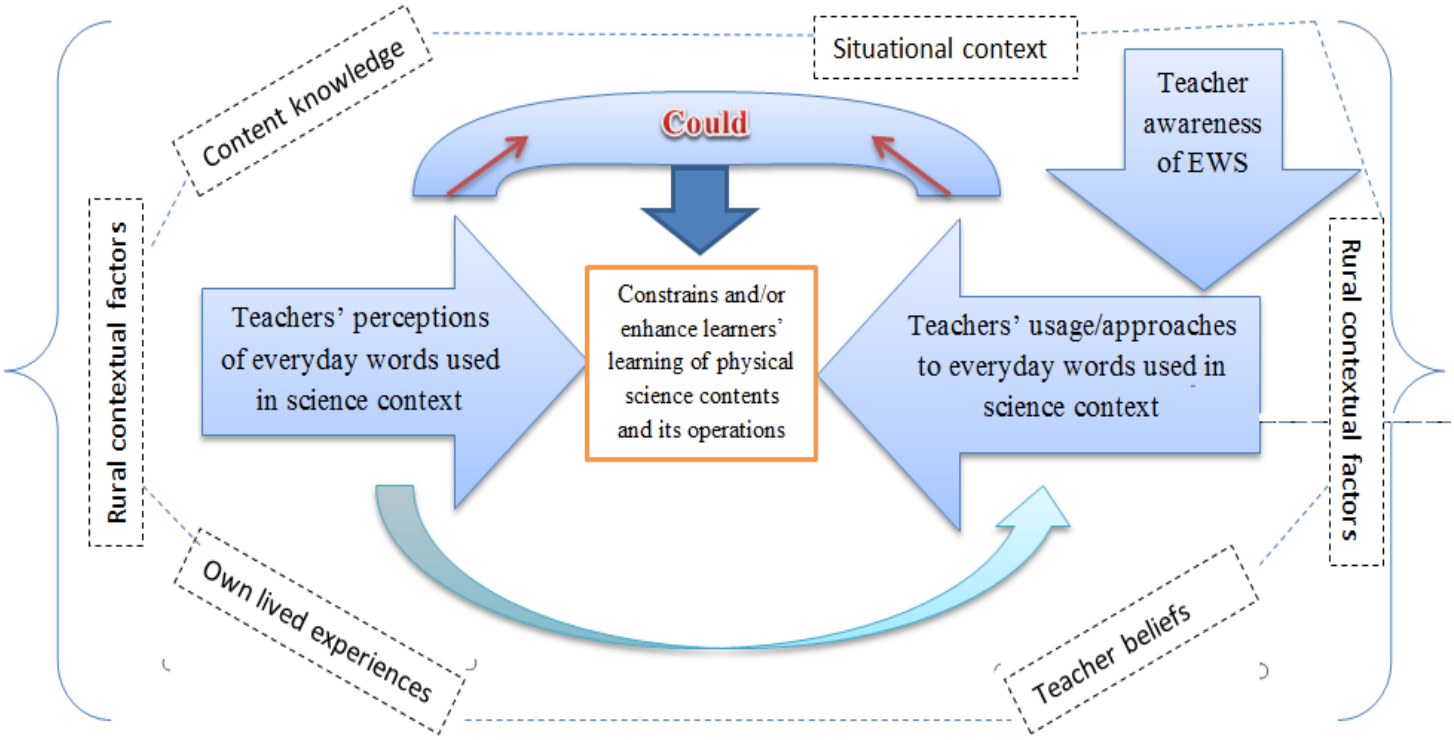


Figure 6.1 Teachers networked factors influencing the teaching of physical science content

6.6. Implications of the findings

Teacher's lack of focus EWS has no potential in assisting learners with border crossing from everyday use to science use of language during teacher mediation of science knowledge. As such learners might be left with everyday meanings of words (EWS) without understanding what actually the teacher wanted them to comprehend in a teaching episode. Moreover, word understanding implicates content knowledge as Haug and Ødegaard (2014) made a link between conceptual knowledge and highly developed word knowledge, so non explanation of words could in part explain why learners perform poorly in physical science subject nationally.

6.7. Recommendations for future research

This study underlines an overarching need for more in-depth studies seeking to unearth teacher influence on the difficulty of EWS and then possibly consolidate a model or a tool for science teachers in addressing language needs within their classrooms. With further discussions, it would be important for comprehensive studies to focus on developing science registers (dictionary) with meanings of everyday words in science context. The researcher envisages research study focusing on multiple rural contexts with sample of both teachers and learners as participants. Given the findings of this study it will be beneficial to examine the impact of intervention intending to equip teachers with skills in noting and dealing with language demands in their classrooms.

Teacher's lack of implicit or explicit mediation of EWS have great impact in learners' learning of science as teachers mediate science knowledge through language and other tools necessitating the clear/explicit explanation of language practices. Therefore, this study recommends encouragement of physical science teachers to handle the science as language and emphasize on explicit explanation of EWS during teaching. Physical science teachers especially those from rural Acornhoek should attend seminars and workshops on the use and impact of science teachers' language including EWS in science classrooms.

6.8. Limitations

Given the fact that this was a case study it was never the study's intention to generalize findings from this research study. Guided by the scope of this study, it was limited to exploring the rural

Acornhoek Grade 10 physical science teachers' perceptions and usage of EWS. however, the result of this study are consistent with those from previous research that science teachers are not aware of the difficulty and functional value of EWS (Oyoo, 2012; Oyoo, 2017), that rural teachers use rigid, rote-learning methods of teaching science (Gardiner, 2008), that teachers do not explicitly explain EWS as encountered in teacher talk (Oyoo, 2012), that teachers believe that language barriers are minimized through the use of code-switching (Dlodlo, 1999) while forgetting that nature of science language being unique to science discourse. The results of this study cannot be generalized to any other rural context and / or other physical science teachers but specific to rural Acornhoek physical science teachers. Additionally, not all the participants were trained in Acornhoek and they do not have their own curriculum but use the national curriculum. However, all the participants use (or supposed to use) English as LOLT like most of the schools in South Africa. So the rural aspect might have some impact on how teachers teach, what they know (teacher knowledge) and other implications.

The use of one camera for video recordings of classroom observations limited the researcher in understanding what utterances were made by teachers when engaging with individual learners in their desks or assisting individual learners on the chalkboard. Furthermore, the dearth of research focusing on teacher's explanation of EWS compelled the researcher to make unilateral decisions in categorizing EWS as being explicitly mediated, implicitly mediated and non-mediated EWS but these concepts were operationalized in chapter 1. Support from literature on categorization of EWS explanation would have made this study's findings more valid even though by putting the actual teacher utterances next to the EWS categorized as mediated or not mediated strengthened the validity of the findings because the reader can always confirm from the referenced text.

It is important to point that I intentionally did not explore how learners' handled or understood EWS within rural classrooms due to the scope, space and time confinements of this study.

6.9. Reflections

The aim of this study was not to criticize rural Acornhoek physical science teachers on how they teach but to unearth their teaching practices with the aim of appreciating current teacher practices more especially language practice within physical science classrooms. So the findings of this study shed some light on what it might mean to teach within rural contexts in South Africa, the

lessons of what we can learn from rural Acornhoek physical science teachers and what could possibly be done to enhance their teaching of science. This study gave insights on rural Acornhoek teachers' perceptions and usage of EWS within physical science classrooms as well as numerous factors that shape teachers perceptions and their usage of science teachers' language including EWS. Moreover, I got to understand from my data that physical science teachers are unaware of the difficulty with EWS encountered within science classroom teaching. Shockingly, was teacher's poor understanding of EWS such as 'phases', 'media', 'noble' yet teachers have used these words during their observed teaching practice.

Through this research, I have learnt that we (science teachers) need to pay attention to issues of science teachers' language including EWS: contextual meanings of everyday words used in physical science. This research enlightened me on the language problems and the importance of context in science language within science classrooms. Lastly, the interview data indicates the importance of language study including in rural remote schools. This can be seen through some participants' utterances where Thabo alluded that *"…its developmental to be with you and to talk to you about the lessons, the things that you are highlighting are also helping me in terms of presenting other lessons better"*. And Simphiwe also agreed with Thabo by saying that *"…from what we had there at least I have learnt something, like the words the yield,… So you see that we learn everyday"*. The above teacher utterances show a degree of teacher reflection on their teaching practices as noted through the research interviews of this study.

If given an opportunity to do this study again, I would do classroom observation, interviews with an additional of video stimulated interviews. Video stimulated interviews would be for teachers to reflect on what exactly they said, how they said and possibly with reasoning of why they approached especially EWS the way they did. Above all these challenges, doing this research study was a worthwhile experience. Furthermore, one of the ways in which science teachers' language can be approached is to target science words (EWS & technical words) during teaching with specific approaches that teachers could use. With considerations of Bravo et al. (2006) and Thompson and Rubenstein (2000) approach to vocabulary building, I suggest the following as a working model towards teacher and learner contextual proficiency in the language used in (as) science. Teachers should target focussed set of words (both technical and non-technical, including EWS), in so doing, they need to provide multiple exposure to science terms through

multiple modalities (verbally, written, practical work) and in the process they need to systematically and explicitly introduce terms in a semantically networked way, making connections between the targeted words and words learners already know (Bravo et al., 2006).

REFERENCES

Abd-El-Khalick, F. (2013). Teaching with and about nature of science, and science teacher knowledge domains. *Science & Education*, *22*(9), 2087-2107.

Acker, D., & Gasperini, L. (2008). Education for Rural People: What have we learned?. *Journal of International Agricultural and Extension Education*, *15*(1), 25-34.

Adedeji, S. O., & Olaniyan, O. (2011). *Improving the conditions of teachers and teaching in rural schools across African countries*. Addis Ababa, Ethiopia: UNESCO-IICBA.

Adler, J. (2001). *Teaching Mathematics in multilingual classrooms*. Dortrecht: Kluwer Academic Publisher.

Aguiar, G. O., Mortimer, F. E., & Scott, P. (2010). Learning from and Responding to Students' Questions: The Authoritative and Dialogue Tension. *Journal of Research in Science Teaching*, *47*(2), 174 -193.

Aikenhead, G. S. (2003, August). Review of research on humanistic perspectives in science curricula. In *4th Conference of the European Science Education Research Association (ESERA), Research and the Quality of Science Education. Noordwijkerhout, The Netherlands (august 19-23)*.

Aikenhead, G.S. (1996). Science Education: Border Crossing into the Subculture of Science. *Studies in Science Education*, 27: 1-52.

Al-Darwish, S. (2012). The role of teacher questions and the Socratic method In EFL classrooms in Kuwait. *World Journal of Education*, *2*(4), 76.

Babbie, E. R. (2011). *Introduction to social research*. Wadsworth Cengage learning.

Babbie, E. R., & Mouton, J. (2007). Qualitative methods of Data sampling. *The practice of social research*, *7*, 187-193.

Baine, D., & Mwamwenda, T. (1994). Education in Southern Africa: Current conditions and future directions. *International review of education*, *40*(2), 113-134.

Balfour, R. J. (2012). Rurality research and rural education: Exploratory and explanatory power. *Perspectives in Education*, *30*(1), 9.

Balfour, R. J., Mitchell, C., & Moletsane, R. (2008). Troubling contexts: Toward a generative theory of rurality as education research. *Journal of Rural and Community Development*, *3*(3), 95-107.

Bassey, M. (1999). *Case Study Research in Educational Settings*. Buckingham, UK: Open University Press.

Bengtsson, M. (2016). How to plan and perform a qualitative study using content analysis. *NursingPlus Open*, *2*, 8-14.

Bilbao-Osorio, B., Dutta, S., & Lanvin, B. (2014). The Global Information Technology Report 2014. In *World Economic Forum* (pp. 1-383).

Bird, E. and Welford, G. (1995). The effect of language on the performance of second language students in science examinations. *International Journal of Science Education* 17 (3), 389-97.

Bravo, M.A., Cervetti, G.N., Hiebert, E.H., & Pearson, P.D. (2006). From passive to active control of science vocabulary. In D.W. Rowe, R. Jiménez, D. Compton, D. Dickinson, Y. Kim, K. Leander, & V. J. Risko (Eds.), *56th Yearbook of the National Reading Conference* (pp. 264-275). Oak Creek, WI: NRC.

Brenzinger, M. (2017). Eleven official languages and more: Legislation and Language Policies in South Africa. *Revista de Llengua i Dret*, (67).

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

Bulman, L. (1985). *Teaching language and study skills in Secondary Science*. Heinemann Educational: London.

Burrell, G., & Morgan, G. (1979). *Sociological paradigms and organisational analysis: Elements of the sociology of corporate life*. London: Heinemann

Carlisle, J. F., Flemming, J. E., & Gudbrandsen, B. (2000). Incidental Word Learning in Science Classes. *Contemporary Educational Psychology*, 25, 184–211.

Carrim, N., & Soudien, C. (1999). Critical antiracism in South Africa. *Critical multiculturalism: Rethinking multicultural and antiracist education*, 153-171.

Cassels, J. R. T. & Johnstone, A. H. (1985). *Words that Matter in Science*. London: Royal Society of Chemistry.

Catanzaro, M. (1988). Using qualitative analytical techniques In: N. F. Woods, & M. Catanzaro (Eds.), *Nursing: research theory and practice* (pp. 437–456). St. Louis: The CV Mosby Company.

Childs, M. (2016). Reflecting on translanguaging in multilingual classrooms: Harnessing the power of poetry and photography. *Educational Research for Social Change*, *5*(1), 22-40.

Childs, P. E. (2006). The Problems with Science Education: "The more things change, the more they are the same". In *Proceedings of SMEC Conference. http://chemistrynetwork. pixel-online. org/data/SMO_db/doc/20_peter% 20childs% 20problems% 20with% 20science% 20eductaion. pdf.*

Childs, P. E., Markic, S., & Ryan, M. C. (2015). The Role of Language in the Teaching and Learning of Chemistry. In Garcia-Martinez, J. & Serrano-Torregrosa, E (Eds.), *Chemistry Education: best practices, opportunities and trends* (pp. 421-446). Weinheim, Germany: Wiley-VCH.

Choy, S. C., & Cheah, P. K. (2009). Teacher perceptions of critical thinking among students and its influence on higher education. *International Journal of teaching and learning in Higher Education*, *20*(2), 198-206.

Christie, F. (1989). Language development in education. In R. Hasan & J. R. Martin (Eds.), *Language development: Learning language, learning culture*, *27*, 152-198.

Clerk, D. & Rutherford, M. (2000). Language as a confounding variable in the diagnosis of misconceptions. *International Journal of Science Education*, 22(7), 703-717.

Cohen, L. M., & Manion, L. l. & Morrison, K. (2007). *Research methods in education*, *6*.

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

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

Creswell, J. W. (2007). *Educational research: Planning, conducting, and evaluating quantitative*. *New Jersey: Upper Saddle River*.

Creswell, J. W. (2007). *Qualitative enquiry and research design: Choosing among five approaches*. *US: Sage publications Ltd*.

Creswell, J. W. (2009). Editorial: Mapping the field of mixed methods research. *Journal of Mixed Methods Research*, *3*(2), 95-108.

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage Publications.

Creswell, J.W. (2012). *Education Research: Planning, conducting, and evaluating quantitative and qualitative research* (4th Ed). USA, Pearson Education Inc.

Dagher, Z. R. (1995). Analysis of Analogies Used by Science Teachers. *Journal of Research in Science Teaching*, *32*(3), 259 - 270.

Daniels, H. (2007). Pedagogy. In H. Daniels, M. Cole, & J. V. Wertsch (Eds.), *The Cambridge companion to Vygotsky* (pp. 307-332). New York: Cambridge University Press.

Dempster, E. R., & Reddy, V. (2007). Item readability and science achievement in TIMSS 2003 in South Africa. *Science Education*, *91*(6), 906-925.

Denzin, N.K. & Lincoln, Y. S.(2004). *Handbook of Qualitative Research.* Thousand Oaks: Sage

Department of Basic Education (DBE). (2010). *The Status of The Languages of Learning and Teaching (LOLT) in South African Public Schools: A Quantitative Overview* (pp. 1-40). Pretoria: Department of Basic Education.

Department of Basic Education (DBE). (2011). *Curriculum Assessment Policy Statement (CAPS), Grades 10–12: Physical Sciences*. Pretoria: Government Printer.

Department of Basic Education (DBE). (2015). *National Senior Certificate Examination: Diagnostic Report.* Pretoria: Government Printer. pp. 1- 300.

Department of Basic Education (DBE). (2016). *National Senior Certificate Examination: Diagnostic Report*. Pretoria: Government Printer.

Department of Basic Education (DBE). (2018). *National Senior Certificate: Diagnostic Report (Part 1).* pp. 1-195.

Department of Basic Education (DBE). (2018). *RURAL EDUCATION DRAFT POLICY*.

Department of Basic Education. (2011). C*urriculum and Assessment Policy Statement Grades 4-6: English home language*. Pretoria: Government Printing Works.

Department of Basic Education. (2012). *Annual Report 2011/2012.* Pretoria: Government Printer.

Department of Education (DoE). (1997). *Language in Education Policy*. Pretoria: Government Press.

Dhurumraj, T. (2013). *Contributory factors to poor learner performance in Physical Sciences in KwaZulu-Natal Province with special reference to schools in the Pinetown District.* (Unpublished master's research report). University of South Africa.

Djité, P. G. (2008). The nexus between education, learning, and language. In *Globalization and Languages: Building on our Rich Heritage Conference on Globalization and Heritage*.

Dlodlo, T.S. (1999). Science Nomenclature in Africa: Physics in Nguni. *Journal of Research in Science Teaching. VOL. 36, NO. 3, pp. 321–33.*

Doolin, B. (1998). Information technology as disciplinary technology: being critical in interpretive research on information systems. *Journal of Information Technology*, *13*(4), 301-311.

Driver R, Asoko H, Leach J, Mortimer E & Scott P. (1994). Constructing scientific knowledge in the classroom. *Educational Researcher, 23* (7), 5-12.

Driver, R. (1989). Students' conceptions and the learning of science. *International Journal of Science Education, 11*(5), 481-490.

du Plooy, L., & Zilindile, M. (2014). Problematising the concept epistemological access with regard to foundation phase education towards quality schooling. *South African Journal of Childhood Education, 4*(1), 187-201.

Duit, R. & Treagust, D.F. (1998).Learning in science- from behaviourism towards social constructivism and beyond. In B. Fraser and K Tobin (Eds.), *International handbook of science education, Part 1*. (pp. 3-25). Dordrecht, The Netherlands: Kluwer.

Eisenhart, M. (1991). Conceptual Frameworks for Research Circa 1991: Ideas from a Cultural Anthropologist; Implications for Mathematics Education Researchers. *Paper presented at*

the Proceedings of the Thirteenth Annual Meeting North American Paper of the International Group for the Psychology of Mathematics Education, Blacksburg, Virginia, USA

Elferink, M., Kirstein, W., Maclachlan, L., Pillay, N., Rens, L., Roos, J., & White, M. (2012). *Grade 10 Physical Sciences: Teacher's Guide*. Johannesburg: Heinemann Publishers (Pty) Ltd.

Erdogan, N. (2016). Sociocultural Perspective of Science in Online Learning Environments. Communities of Practice in Online Learning Environments. *International Journal of Education in Mathematics, Science and Technology*, *4*(3), 246-257.

Farell, M. P. & Ventura, F. (1998). Words and understanding in physics. *Language and Education, 12* (4), 243-253. http://dx.doi.org/10.1080/09500789808666752

Ferreira, J. G. (2011). Teaching of Life Sciences to English second language learners: What do teachers do? *South African Journal of Education*, 31: 102-113.

Flyvbjerg, B. (2006). Five Misunderstandings About Case-Study Research. *Qualitative Inquiry, 12*(2), 219-245.

FORBES/ PROFILE / Patrice Motsepe. (n.d.). Retrieved on 23 February 2017, from https://www.forbes.com/profile/patrice-motsepe/

Freebody, P. (2003). *Qualitative research in education: Interaction and practice.* London: SAGE Publications.

Gardiner, M. (2008). Education in rural areas. *Issues in education policy, 4*, 1-33.

Gardner, P.L. (1971). *Project SWNG- Scientific words: New Guinea. Faculty of Education*, Monash University: Melbourne

Gardner, P.L. (1972). *'Words in Science': An investigation of Non-Technical vocabulary difficulties amongst form I, II, III and IV science students in Victoria*. Australia Science Project: Melbourne.

Gardner, P.L., (1977). *Logical Connectives in Science: An investigation of difficulties in comprehending logical connectives in both scientific and everyday contexts amongst junior secondary school science students in Victoria*. Faculty of Education, Monash University: Melbourne.

Gardner, P.L., (1980). Identification of specific difficulties with logical connectives in science among secondary school science students. *Journal of Research in Science Teaching*, 17 (30), 223 – 229.

Giancoli, D. C. (2005). *Physics: Principles with Applications*. (6th ed.). Canada: Pearson Education.

Glasersfeld, E. V. (1992). A constructivist's view of learning and teaching. *Research in physics learning: Theoretical issues and empirical studies*, 29-39.

Gopaul, M. (2009). *The significance of rural areas in South Africa for tourism development through community participation with special reference to Umgababa, a rural area located in the province of KwaZulu-Natal* (Doctoral dissertation).

Graneheim, U. H., & Lundman, B. (2004). Qualitative content analysis in nursing research: concepts, procedures and measure to achieve trustworthiness. *Nurse Education Today, 24*, 105–112.

Grant, C., & Osanloo, A. (2014). Understanding, Selecting, and Integrating a Theoretical Framework in Dissertation Research: Creating the Blueprint for Your" House". *Administrative Issues Journal: Education, Practice, and Research*, *4*(2), 12-26.

Greenwood, J. (1990). Language in the science classroom. *Science Education Newsletter*, (89), 1-3.

Halliday, M. A. (1993). Towards a language-based theory of learning. *Linguistics and Education*, *5*(2), 93-116.

Halliday, M. A., & Martin, J. R. (1993). *Writing science: Literacy and discursive power (Vol. 8).* Taylor & Francis.

Hammond, J. (2001). *Scaffolding: Teaching and Learning in Language and Literacy Education*. Primary English Teaching Assoc., PO Box 3106, Marrickville, New South Wales, 2204, Australia.

Hardré, P. L., & Sullivan, D. W. (2008). Teacher perceptions and individual differences: How they influence rural teachers' motivating strategies. *Teaching and Teacher Education*, *24*(8), 2059-2075.

Harvey, J. (2011). *A sociocultural-theory-based study of the impact of mediation during post-observation conferences on language teacher learning* (Doctoral Dissertation). Retrieved from http://scholarcommons.usf.edu/etd/3727

Hassard, J., & Dias, M. (2009). *The Art of Teaching Science*. London: Routledge NY.

Haug, B. S. & Odegaard, M. (2014). From words to Concepts: Focusing on Word Knowledge When Teaching for Conceptual Understanding within an Inquiry – Based Science Setting. *Research in Science Education*, 44, 777 – 800.

Henning, E. (2004). *Finding your way in qualitative research*. Pretoria: Van Schaik.

Hlalele, D. (2012). Exploring rural high school learners' experience of mathematics anxiety in academic settings. *South African Journal of Education*, *32*(3), 267-278.

Hodson, D. (2009). Teaching and learning about science: *Language, theories, methods, history, traditions and values*. Rotterdam: Sense Publishers.

Hodson, D., & Hodson, J. (1998). From Constructivism to Social Constructivism: A Vygotskian Perspective on Teaching and Learning Science. *School Science Review, 79*, (289), 33-41.

Howie, S., & van Staden, S. (2012). *South African Children;s Reading Literacy Achievement - PIRLS and prePIRLS 2011 Summary of the key results (Media briefing).* Pretoria: Centre for Evaluation and Assessment.

Hsieh H. F., & Shannon S. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research*. 15, 1277– 1288.

Hytten, K., & Bettez, S. C. (2011). Understanding education for social justice. *The Journal of Educational Foundations*, *25*(1/2), 7.

Irvine, A. (2011). Duration, dominance and depth in telephone and face-to-face interviews: A comparative exploration. *International Journal of Qualitative Methods*, *10*(3), 202-220.

Johnson, B. & Christensen, L. (2008). *Focus groups: A practical guide for applied research*. London: SAGE Publications.

Johnson, N. A. (1994). The pervasive, persuasive power of perceptions. *The Alberta Journal of Educational Research*, XL (4): 475-497.

John-Steiner, V., & Mahn, H. (1996). Sociocultural approaches to learning and development: A Vygotskian framework. *Educational psychologist*, *31*(3-4), 191-206. DOI: 10.1080/00461520.1996.9653266.

Karpov, Y. (2003). Vygotsky's doctrine of scientific concept: It's role for contemporary education. In A. Kozulin, B. Gindis, S. Ageyev & S. Miller (Eds.). *Vygotsky's Educational Theory in Cultural Context*. Cambridge, Cambridge University Press.

Khetoa, S. G. (2016). *Factors constraining Grade 12 learners' achievement in Sesotho Home Language* (Unpublished master's research report, University of the Free State, South Africa).

Khisty, L. L. (1993). A naturalistic look at language factors in mathematics teaching in bilingual classrooms. *Paper presented at the Proceedings of the third National Research Symposium on Limited English Proficient Student Issues: Focus on Middle and High School Issues.*

Kozulin, A. (1990). *Vygotsky's psychology: A biography of ideas*. Hertfordshire, UK: Harvester, Wheatsheaf.

Kriek, J., & Grayson, D. (2009). A holistic professional development model for South African Physical Science Teachers. *South African Journal of Education*., 29(2).

Kurwa, G. M. (2016). *South African physical science teachers' classroom language for enhanced understanding of science concepts* (Unpublished master's research report, University of the Witwatersrand, Johannesburg).

Lantolf, J. P., & Thorne, S. L. (2006). *Sociocultural theory and the genesis of second language development*. Oxford, UK: Oxford University Press.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*: Cambridge university press.

Leach, J., & Scott, P. (2003). Individual and Sociocultural Views of Learning in Science Education. *Science and Education, 12*, (1), 91-113

Lederman, N. G., Antink, A., & Bartos, S. (2012). Nature of science, scientific inquiry, and socio-scientific issues arising from genetics: A pathway to developing a scientifically literate citizenry. *Science & Education*, *23*(2), 285-302.

Leedy, P. D., & Ormrod, J. E. (2010). Practical Research: Planning and Design. *New Jersey, Pearson Merill Prentice hall*.

Legari, K. (2004). *Teaching Physical Science in rural (under-resourced) secondary schools*. (Unpublished master's research report, University of KwaZulu-Natal, Durban).

Leitch, C. M., Hill, F. M., & Harrison, R. T. (2010). The philosophy and practice of interpretivist research in entrepreneurship: Quality, validation, and trust. *Organizational Research Methods, 13*(1), 67-84.

Lemke, J. L. (1990). *Talking Science: Language, learning and values*. Abex: New Jersey: Norwood.

Lemke, J. L. (1998). Multimedia literacy demands of the scientific curriculum. *Linguistics and Education, 10*(3), 247-271.

Lemke, J. L. (2001). Articulating communities: Sociocultural perspectives on science education. *Journal of Research in Science Teaching 38*(3), 296-316.

Leonard, J., Chamberlin, S. A., Johnson, J. B., & Verma, G. (2016). Social justice, place, and equitable science education: Broadening urban students' opportunities to learn. *The Urban Review, 48*(3), 355-379.

Lester, F. K. (2005). On the theoretical, conceptual, and philosophical foundations for research in mathematics education. *Zdm, 37*(6), 457-467.

Letts, L., Wilkins, S., Law, M., Stewart, D., Bosch, J., & Westmorland, M. (2007). Guidelines for critical review form: Qualitative studies (Version 2.0). *McMaster University Occupational Therapy Evidence-Based Practice Research Group*.

Lewis, A. (2001). The issue of perception: some educational implications. *Educare*, *30*(1), 272-288.

Lindkvist, K. (1981). *Approaches to contextual analysis. In K. E. Rosengren (Ed.), Advances in content analysis (pp. 33-41*). Beverly Hills, CA: Sage.

Louisa, M., Veiga, F., Pereira, D. J. C., & Maskill, R. (1989). Teachers' language and pupils' ideas in science lessons: can teachers avoid reinforcing wrong ideas? *International Journal of Science Education, 11*(4), 465-479.

Lowe, I. (2009). *A question of terminology*. Accessed on 23 February 2018 from Http//www.scientificlanguage.com/esp/terminology.pdf

Lyle, S. (2008). Dialogic teaching: Discussing theoretical contexts and reviewing evidence from classroom practice. *Language and education*, 22(3), 222-240.

Lyman, F. T. (1981). The responsiveness classroom discussion: The inclusion of all students. In A. Anderson (Ed.), *Mainstreaming digest* (pp. 109–113). College Park: University of Maryland Press.

Maclellan, E., & Soden, R. (2003). Expertise, expert teaching and experienced teachers'knowledge of learning theory. *Scottish Educational Review, 35*(2), 110-120.

Makgato, M. (2007). Factors associated with poor performance of learners in mathematics and physical science in secondary schools in Soshanguve, South Africa. *Africa Education Review, 4*(1), 89-103.

Mammino, L. (2010). The essential role of language mastering in science and technology education. *International Journal of Education. Inf. Technol*., 4 (3), 139-148.

Marshall, S., & Gilmour, M. (1990). Problematical words and concepts in physics education: a study of Papua New Guinean students' comprehension of non-technical words used in science. *Physics Education, 25*(6), 330-337.

Martin, R. B., & Dean, S. J. (1964). Implicit and explicit mediation in paired-associate learning. *Journal of Experimental Psychology, 68*(1), 21.

Masinire, A. (2015). Recruiting and retaining teachers in rural schools in South Africa: Insights from a rural teaching experience programme. *Australian and International Journal of Rural Education, 25*(1), 2-14.

Masinire, A., Maringe, F., & Nkambule, T. (2014). Education for rural development: Embedding rural dimensions in initial teacher preparation. *Perspectives in Education*, *32*(3), 146-158.

Matthews, M. R. (1998). Introductory Comments on Philosophy and Constructivism in Science Education (pp. 1-10). In M. R. Matthews (Ed), *Constructivism in Science Education*. Dordretcht: Kluwer Academic Publishers.

Mayring, P. (2014). Qualitative content analysis: theoretical foundation, basic procedures and software solution. pp. 1-143. Retrieved from http://nbn-resolving.de/urn:nbn:de:0168-ssoar-395173

McComas, W. F. (Ed.) (2014). The Language of Science Education: *An Expanded Glossary of Key Terms and Concepts in Science Teaching and Learning*. Rotterdam: Sense Publishers.

McCracken, J. D., & Barcinas, J. D. T. (1991). High School and Student Characteristics in Rural and Urban Areas of Ohio.

McMillan, J. H. (2012). *Educational Research: Fundamentals for the consumer*. (6th ed.). Cape Town: Pearson Education, Inc.

McMillan, J., & Schumacher, S. (2006). *Research in Education Evidence–Based Inquiry*. Boston: Pearson Education.

McMillan, J.H. & Schumacher, S. (2010). *Research in Education: Evidence-based inquiry*. (7th Ed.) Pearson Education, Inc. New Jersey: Upper Saddle River.

Meana, W. E. (2009). *Curriculum innovation in teacher education: Exploring conception among Tanzanian teacher educators*. University Press. Åbo Akademi: Åbo

Menon, S., & Mukundan, J. (2010). Analysing collocational patterns of semi-technical words in science textbooks. *Pertanika Journal of Social Sciences and Humanities*, *18*(2), 241-258.

Mercer, N. (1995). *The guided construction of knowledge: talk amongst teachers and learners*. Clevedon: Multilingual Matters Ltd.

Mercer, N., Wegerif, R., & Dawes, L. (1999). Children's talk and the development of reasoning in the classroom. *British educational research journal*, *25*(1), 95-117.

Merriam, S. B. (2002). *Introduction to qualitative research. Qualitative research in practice: Examples for discussion and analysis*, 3-17. Jossey-Bass Inc Pub.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded source book* (2nd ed.). Newbury Park, CA: Sage.

Mitchell, C., De Lange, N., Balfour, R., & Islam, F. (2011). Transforming teacher education? A rural teacher education project experience. *School–university partnerships for educational change in rural South Africa*, 59-82.

Mji, A., & Makgato, M. (2006). Factors Associated with high school learners' performance: A spotlight on Mathematics and Physical Sciences. *South African Journal of Education*, 26 (2), 253 –266.

Moletsane, R. (2012). Repositioning educational research on rurality and rural education in South Africa: Beyond deficit paradigms. *Perspectives in Education*, *30*(1), 1.

Morgan, D. L. (2007). Paradigms lost and pragmatism regained methodological implications of combining qualitative and quantitative methods. *Journal of mixed methods research*, *1*(1), 48-76.

Mortimer, E., & Scott, P. (2003). *Meaning Making In Secondary Science Classrooms*. Philadelphia: Open University Press.

Mortimer, E.F., & Scott, P.H. (2003). *Meaning-making in secondary science classrooms*. Buckingham, UK: Open University Press

Mouton, J. (1996). *Understanding social research*. Van Schaik Publishers.

Msila, V. (2007). From apartheid education to the revised national curriculum statement: Pedagogy for identity formation and nation building in South Africa. *Nordic Journal of African Studies*, *16*(2), 146-160.

Msimanga, A. S. (2013). *Talking science in South African high schools: Case studies of Grade 10-12 classes in Soweto* (Unpublished doctoral thesis, University of the Witwatersrand, Johannesburg).

Mthethwa-Sommers, S. (2014). What Is Social Justice Education?. In *Narratives of Social Justice Educators* (pp. 7-25). Springer, Cham.

Mthiyane, C. C. N. (2016). Pre-service teachers' beliefs and experiences surrounding the use of language in science classrooms: A South African case study. *Nordic Journal of African Studies*, *25*(2), 111-129.

Mukeredzi, T. G. (2016). The" Journey to Becoming" Pre-Service Teachers' Experiences and Understandings of Rural School Practicum in a South African Context. *Global Education Review*, *3*(1), 88-107.

Muralidhar, S. (1991). The role of language in science education: Some reflections from Fiji. *Research in Science Education*, 21, 253 – 262.

Muwanga-Zake, J. W. F. (1998). *Research portfolio*. (Unpublished master's research report, Rhodes University, South Africa)

Namugaya, J., & Habumugisha, I. (2017, February). Current Causes of Girls' Low Performance in Physical Sciences from Hard-to-reach Secondary Schools in Eastern Uganda. *International Journal of Secondary Education.* Vol.5, No. 1, 2017, pp. 12-15. doi: 10.11648/j.ijsedu.20170501.12.

Ncube, E. Z. (2016). *Investigating physical science teachers' classroom use of language during teaching* (Unpublished master's research report, University of the Witwatersrand, South Africa).

Ncube, M. (2014). *Investigating the learners' interpretation of everyday words when used in the physics context in South African classrooms.* (Unpublished master's research report, University of the Witwatersrand, South Africa).

Ndlovu, M. C. (2011). University-school partnerships for social justice in mathematics and science education: the case of the SMILES project at IMSTUS. *South African journal of education*, *31*(3), 419-433.

Njie, B., & Asimiran, S. (2014). Case study as a choice in qualitative methodology. *IOSR Journal of Research and Method in Education*, *4*(3), 35-40.

Nkambule, T. C. (2017). Student teachers' perceptions of a Wits rural teaching experience project: What to learn and improve. *South African Journal of Higher Education*, *31*(1), 191-206.

Nkambule, T., & Mukeredzi, T. G. (2017). Pre-service teachers' professional learning experiences during rural teaching practice in Acornhoek, Mpumalanga Province. *South African Journal of Education*, *37*(3), 1-9.

Nkambule, T., Balfour, R. J., Pillay, G., & Moletsane, R. (2011). Rurality and rural education: Discourses underpinning rurality and rural education research in South African postgraduate education research 1994-2004. *South African Journal of Higher Education*, *25*(2), 341-357.

Okoro, C. O. (2011). The Ideal Teacher and the Motivated Student in a Challenging Environment. *Journal of Educational and Social Research, 1* (3), 107-112.

Opie, C. (2004). Research Approaches. In C. Opie (Ed.), *Doing Educational Research* (pp. 87 - 92). London: SAGE.

Osborne, J. (2007). Science Education for the Twenty First Century. *Eurasia Journal of Mathematics, Science & Technology Education*, *3*(3).

Oyoo, S. & Semeon, N. (2015). The Place of Profiency in the Language of Instruction: The Difficulties Grade 12 Physical Science Learners Encounter with Everyday Words in a Science Context. In Makalela, L (ed). CASAS BOOK SERIES NO. 115: *New Directions in Language and Literacy Education for Multilingualism Classrooms in Africa* (Chapter 2, pp. 39-66). Cape Town : The Centre for Advanced Studies of African Society (CASAS), Website: www.casas.co.za

Oyoo, S. O. (2000). *Understanding of Some Non-Technical Words in Science and Suggestions for Effective Use of Language in Science Classrooms.* (Unpublished master's research report, University of Leeds, England, United Kingdom).

Oyoo, S. O. (2004). *Effective Teaching of Science: The Impact of Physics Teachers' Classroom Language*. (Unpublished doctoral thesis, Faculty of Education: Monash University, Clayton Campus, Melbourne, Victoria, Australia).

Oyoo, S. O. (2005). Science teachers' awareness of the impact of their classroom language. In P.L. Jeffery, *Collection of Papers presented at the AARE 2005 International Education Research Conference, University of Western Sydney, Parramatta, NSW, Australia, 27th November – 1st December 2005*; CD Version ISSN 1324-9320—WWW Version ISSN 1324-9339; Melbourne: The Australian Association for Research in Education.

Oyoo, S. O. (2007). Rethinking Proficiency in the Language of Instruction (English) as a Factor in the Difficulty of School Science. *The International Journal of Learning*, *14* (4), 231 – 242.

Oyoo, S. O. (2009). How physics teachers use and think about language during teaching: The explanations and implications. *The International Journal of Learning, 16*, (2), 169-183

Oyoo, S. O. (2011). Foreign Languages in African Science Classrooms: Perspectives on and approaches to language use during teaching. *Proceedings of the Distance Education and*

Teachers' Training in Africa (DETA) conference. Universidade Eduardo Mondlane, Maputo , Mozambique, pp. 121- 147

Oyoo, S. O. (2012). Language in science classrooms: an analysis of physics teachers' use of and beliefs about language. *Research in Science Education, 42*(5), 849-873.

Oyoo, S. O. (2014). Language of Instruction and Science Learning in African Science Classrooms, In Daniel O. Orwenjo, Martin C. Njoroge, Ruth W. Ndung'u and Phyllis W. Mwangi (Eds); *Multilingualism and Education in Africa: The State of the State of the Art*, (pp. 24 – 49). Cambridge: Cambridge Scholars Publishing.

Oyoo, S. O. (2017). Learner Outcomes in Science in South Africa: Role of the Nature of Learner Difficulties with the Language for Learning and Teaching Science. *Research in Science Education.* pp. 1-22. DOI 10.1007/s11165-016-9528-8.

Oyoo, S. O. (June 2016). When science teachers' use of instructional language during teaching becomes effective teaching of science. *The International Journal of Science, Mathematics and Technology Learning, 23 (2),pp.33-47,*ISSN: 2327 7971(Print), ISSN: 2327-915X (Online)*;* JournalSite: http://ijlsmtl.cgpublisher.com. DOI: 10.18848/2327-7971/CGP/v23i02/33-47.

Ozden, M. (2008). The Effect of Content Knowledge on Pedagogical Content Knowledge: The Case of Teaching Phases of Matters. *Educational sciences: theory and practice*, *8*(2), 633-645.

Patton, M. Q., & Cochran, M. (2002). A guide to using qualitative research methodology. *Medecins Sans Frontiers. Retrieved February*, *14*, 2017.

Phan, H. P. (2012). A Sociocultural Perspective of Learning: Developing a New Theoretical Tenet. *Australian Association for Research in Education (NJ1)*, 1-14.

Piaget, J. (1964). Development and learning. *Journal of Research in Science Teaching*, *40* (Supplement), S8-S18.

Pickersgill, S., & Lock, R. (1991). Student understanding of selected non-technical words in science. *Research in Science & Technological Education*, 9(1), 71-79.

Pizzoli, E., & Gong, X. (2007). How to best classify rural and urban. In *ponencia presentada en la Fourth International Conference on Agriculture Statistics* (pp. 22-24).

Ponelis, S. R. (2015). Using interpretive qualitative case studies for exploratory research in doctoral studies: A case of Information Systems research in small and medium enterprises. *International Journal of Doctoral Studies*, *10*(1), 535-550.

Pozzebon, M. (2004). Conducting and evaluating critical interpretive research: Examining criteria as a key component in building a research tradition. In *Information Systems Research* (pp. 275-292). Springer US.

Probyn, M. J. (2005). Learning science through two languages in South Africa. In *Proceedings of the 4th international symposium on bilingualism. Somerville: Cascadilla Press. Google Scholar*. (pp. 1855-1873).

Prophet, R. B., & Badede, N. B. (2009). Language and student performance in junior secondary science examinations: the case of second language learners in Botswana. *International Journal of Science and Mathematics Education*, *7*(2), 235.

Punch, K. F. (2009). *Introduction to research methods in education*. Sage.

Randolph, W. A, & Blackburn, R. S. (1989). *Managing Organizational Behavior*. Boston, MA: Irwin

Reddy, V. (2005). State of mathematics and science education: schools are not equal. *Perspectives in Education, 23*(3), 125–130.

Reeve, R., & Sharkawy, A. (2014). Science Education for Social Justice Using the Knowledge-Building Communities Model. *Inclusive Education: Socially Just Perspectives and Practices*, 283.

Rice, J. K. (2010). The Impact of Teacher Experience: Examining the Evidence and Policy Implications. Brief No. 11. *National center for analysis of longitudinal data in education research*.

Richards, J. C. (1998). *Beyond training.* Cambridge, UK: Cambridge University Press.

Robbins, S. P. (1991). *Organizational Behavior*. Englewood Cliffs, NJ: Prentice Hall.

Rollnick, M. (2000). Current issues and perspectives on second language learning of science. *Studies in Science Education,* 35, 93 – 122.

Rollnick, M. (2010). *Identifying Potential for Equitable Access to Tertiary Level Science*. New York: Springer. Chapter 8. pp. 153-171.

Rollnick, M., & Rutherford, M. (1996). The use of mother tongue and English in the learning and expression of science concepts: A classroom-based study. *International Journal of Science Education,* 18, 91–103.

Roth, W.-M. (2014). Science language wanted alive: through the dialectical/dialogical lens of Vygotsky and Bakhtin Circle. *Journal of Research in Science Teaching, 51*(8), 1049–1083.

Rubin, A. & Babbie, E. (2010). *Essential research methods for social work*. New York: Brooks/Cole Cengage Learning.

Schaffer, C. (2007). Teaching science to English as a second language students. Retrieved on 20 November 2017 from *https://tspace.library.utoronto.ca/bitstream/1807/9901/1/shaffer.pdf*.

Schoerning, E. (2014). The effect of plain-English vocabulary on student achievement and classroom culture in college science instruction. *International Journal of Science and Mathematics Education, 12*(2), 307-327.

Scott, D., & Morrison, M. (2005). *Key ideas in educational research*. A&C Black.

Scott, P. (1998). Teacher Talk and Meaning Making in Science Classrooms: a Vygotskian Analysis and Review. *Studies in Science Education*, 32; 45-80.

Scott, P., Mortimer, E., & Aguiar, O. (2006). The tension between authoritative and dialogic discourse: A fundamental characteristic of meaning-making interactions in high school science lessons. *Science Education, 90*, 605-631.

Scott, P., Mortimer, E., & Ametller, J. (2011). Pedagogical link-making: a fundamental aspect of teaching and learning scientific conceptual knowledge. *Studies in Science Education, 47*(1), 3-36.

Seah, L. H., & Yore, L. D. (2017). The roles of teachers' science talk in revealing language demands within diverse elementary school classrooms: a study of teaching heat and temperature in Singapore. *International Journal of Science Education, 39*(2), 135-157.

Setati, M., Adler, J., Reed, Y., & Bapoo, A. (2002). Incomplete Journeys: Code-switching and Other Language Practices in Mathematics, Science and English Language Classrooms in South Africa. *Language and Education, Vol. 16*(2), 128 - 149.

Shapin, S., & Schaffer, S. (1985). *Leviathan and the air-pump.* Princeton, NJ: Princeton University Press.

Shneiderman, B., & Plaisant, C. (2005). Strategies for evaluating information visualization tools: multi-dimensional in-depth long-term case studies. In *Proceedings of the 2006 AVI workshop on Beyond time and errors: novel evaluation methods for information visualization* (pp. 1-7). ACM.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational researcher, 15*(2), 4-14.

Simelane, T. (2014). *The Language of Instruction and Teaching of Natural Sciences: Messages from South African Grade 9 Leaners' Meanings of Non-technical Words.* (Unpublished BSc Honours research report, University of the Witwatersrand, Johannesburg, South Africa).

Smith, A. M. (2012). Research methodology: A step-by-step guide for beginners. *Nurse Education in Practice, 12*(3), e25.

Smith, L.K. (2005). The impact of early life history on teachers' beliefs: in-school and out-of-school experiences as learners and knowers of science. *Teachers and Teaching: Theory and Practice 11*(1): 5–36.

Spaull, N. (2013). South Africa's education crisis: The quality of education in South Africa 1994-2011. *Johannesburg: Centre for Development and Enterprise*.

St Onge, J., & Eitel, K. (2017). Increasing Active Participation and Engagement of Students in Circle Formations. *Networks: An Online Journal for Teacher Research*, *19*(1), 7.

Stake, R. E. (1995). *The art of case study research*. Sage.

Statistics South Africa. (2003). *Census 2001: How the count was done* (No. 3). Statistics South Africa.

Stelmach, B. L. (2011). A synthesis of international rural education issues and responses. *The Rural Educator*, *32*(2), 32-42.

Stepanek, J. (2000). Mathematics and Science Classrooms: Building a Community of Learners. It's Just Good Teaching.

Stevenson, A., & Waite, M. (Eds.) (2011). *Concise Oxford English Dictionary. (12th ed.).* Cape Town: Oxford University Press. 1-1682.

Stevenson, A., & Waite, M. (Eds.). (2011). *Concise Oxford English Dictionary.* (12th ed.). Cape Town: Oxford University Press.

Strömdahl, H. R. (2012). On discerning critical elements, relationships and shifts in attaining scientific terms: The challenge of polysemy/homonymy and reference. *Science & Education, 21*(1), 55-85.

Sutton, C. (1992). *Words, science and learning*: McGraw-Hill International.

Sutton, C. (1996). The Scientific Model as a form of speech. In Welford, G., Osborne, J. and Scott, P. (Eds.), *Research in Science Education in Europe*, London: Falmer Press, 143-152.

Tao, P. K. (1994). Comprehension of non-technical words in science: The case of students using a "foreign" language as a medium of instruction. *Research in science education*, 24, 322-330.

Tenza, S. P., Gilson, P., Mjoli, B., Hough, S., & Ntuli, S. (2012). *Mathematical Literacy: Learner's books. Grade 11*. Cape Town: Shuter & Shooter Publishers. 1-471.

Tesch, R. (1990). Qualitative research: *Analysis types and software tools*. London: Falmer Press.

Thalheimer, W. (2003). The learning benefits of questions. Retrieved November 01, 2017, from *http://www.worklearning.com/ma/PP_WP003.asp*

Thanh, N. C., & Thanh, T. T. (2015). The interconnection between interpretivist paradigm and qualitative methods in Education. *American Journal of Educational Science*, *1*(2), 24-27.

Thompson, D. R., & Rubenstein, R. N. (2000). Learning mathematics vocabulary: Potential pitfalls and instructional strategies. *The Mathematics Teacher*, *93*(7), 568-574.

Thorne, K., Gericke, N. M., & Hagberg, M. (2013). Linguistic Challenges in Mendelian Genetics: Teachers' Talk in Action. *Science Education, 97* (5): 695-722.

TIMSS (2011). The South African Perspective. *Human Sciences Research Council*. pp. 1-12.

Topçiu, M., & Myftiu, J. (2015). Vygotsky Theory on Social Interaction and its Influence on the Development of Pre-School Children. *European Journal of Social Sciences Education and Research, 4*(1), 172-179.

Treagust, D. F., & Duit, R. (2009). Multiple perspectives of conceptual change in science and the challenges ahead. *Journal of Science and Mathematics Education in Southeast Asia, 32*(2), 89-104.

Tshotsho, B. P. (2013). Mother tongue debate and language policy in South Africa. *International Journal of Humanities and Social Science*, *3*(13), 39-44.

Uzuntiryaki, E., & Geban , Ö. (2005). Effect of conceptual change approach accompanied with concept mapping on understanding of solution concepts. *Instructional Science, 33*(4), 311-339.

Van Dijk, T. A. (2007). Macro contexts. In U. D. S. Lottgen u. J. S. Sanchez (Eds.), *Discourse and international relations (pp- 3-26*). Bern: Lang.

Van Laere, E., Aesaert, K., & van Braak, J. (2014). The Role of Student's Home Language in Science Achievement: A multilevel approach. *International Journal of Science Education, 36*(16), 2772-2794.

Venkat, H., Adler, J., Rollnick, M., Setati, M., & Vhurumuku, E. (2009). Mathematics and science education research, policy and practice in South Africa: What are the relationships?. *African Journal of Research in Mathematics, Science and Technology Education*, *13*(sup1), 5-27.

von Glasersfeld, E. (1991). A constructivist's view of learning and teaching. In R. Duit, F. Goldberg & H. Niedderer (Eds.), *Research in physics learning: Theoretical issues and empirical studies*. Kiel, Germany: Proceedings of an international workshop.

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

Vygotsky, L. S. (1986). *Thought and language*. Cambridge, MA: MIT Press.

Walker, V. S. (2000). Valued segregated schools for African American children in the South, 1935-1969: A review of common themes and characteristics. *Review of Educational Research*, *70*(3), 253-285.

Ward, M. (2007). Rural education. *India Infrastructure Report 2007*, 286-317.

Wellington, J. (1994). Language in science education (pp. 168–190). In J. Wellington (Ed.), *Secondary science: Contemporary issues and practical approaches*. London: Routledge.

Wellington, J., & Osborne, J. (2001). *Language and literacy in science education*. McGraw-Hill Education (UK).

Wells, G. (1999). *Dialogic inquiry: Towards a socio-cultural practice and theory of education*. Cambridge University Press.

Wertsch, J. V. (1985). *Vygotsky and the social formation of mind. Cambridge*, MA: Harvard University Press.

Wertsch, J. V. (1998). *Mind as action*. Oxford, UK: Oxford University Press.

Wertsch, J. V. (2007). Mediation. In H. Daniels, M. Cole, & J. V. Wertsch, (Eds.). *The Cambridge Companion to Vygotsky*. New York: Cambridge University Press.

Wilson, J. M. (1999). Using words about thinking: Content analyses of chemistry teachers' classroom talk. *International Journal of Science Education*, *21*(10), 1067-1084.

Yin, R. K. (2013). *Case study research: Design and methods*: Sage publications.

Zhang, Y., & Wildemuth, B. M. (2016). Qualitative analysis of content. *Applications of social research methods to questions in information and library science*, *318*.

APPENDICES

APPENDIX 1: Classroom Observation Schedule

I will take the role of a non-participant observer. The following will be the specific concerns during classroom observations:

- Is the classroom communication a one way transmission of content from teacher to learners or teacher-learner and learner-learner interactions is encouraged?
- What EWS are used by the teacher? Does the teacher explain (explicitly or implicitly) or provide the contextual meanings of these words or not? If so, then is there a clear approach in doing this?
- In sharing the contextual meanings of non-technical words used during teaching, does the teacher explore the other possible meanings of these words? Any other approaches used?
- Is there any approach to science language used by the teacher? If yes, what is the used approach?

APPENDIX 2: Interview Schedule

Introductory questions:

1) Where did you attend your primary and secondary schools?
2) Where did you train to be a teacher?
3) When did you train to be a teacher?
4) What were your subjects of specialization in your teacher training?
5) How long have you been teaching physical science?
6) What other subjects are you currently teaching?

Research Interview Questions

1. What language do you usually use when teaching physical science in your class?
2. Which other languages do you use to emphasize or enhance the process of learning?
3. How does English language shape learners' understanding of physical science concepts?
4. What difficulties, if any, does teaching physical science through English language has on learners understanding of science concepts?
5. Do you think it is important to use science specific language when a teacher teaches physical science concepts? Why?
6. From your practice (experience), do you think it is advisable for a teacher to use general English language to explain science concepts?
7. What challenges, if any, do you experience while teaching physical science in grade 10?
8. Have you observed any language challenges that learners experience when explaining or in science assessment?
9. To what extent is the language used in science textbooks, examination papers presents any challenges to your learners?
10. Do you think there is a difference between the meanings of commonly used English words and the meaning of the same words in science classroom? For example, the meaning of sensitive (sensitive instruments), spontaneous (spontaneous chemical reactions).
11. Should science learners be aware of this difference? Why or Why not?
12. Do you sometimes use words that are used in general English talks?
13. Do you explain the meaning of these words to your learners?
14. Do you think it is difficult to use science specific language while teaching? Why or Why not?

Purposefully select some non-technical words (metarepresentational and logical connectives) used by the teacher during science teaching.

1. During your teaching you used this word **(…)**, what does this word mean to you?
2. Why did you or didn't you explain this word? (If explained, do you think it was or should be necessary to explain it?)
3. Is there anything you like to tell or ask me about?

Thank you for your time and voluntary participation in the interview

APPENDIX 3: Sample of Interview Transcript for Ayanda

The interview session happened immediately after the teacher's lesson since she did not have any other lesson to teach after this interview session.

Researcher: That is quite something. So I just want to ask few things and then uhhh I understand your busy schedule. I don't have to take much of your time. But I just want to ask, where did you attend your primary and secondary school? Like, do you remember when and where?

Ayanda: I attended in Zimbabwe.

Researcher: Ohh in Zimbabwe…

Ayanda: Yes, both the primary and secondary

Researcher: And secondary there as well..

Ayanda: Technically so (inaudible) this is more to the (inaudible)

Researcher: How did they teach you physical science? Did you have labs

Ayanda: yes we did

Researcher: at high school?

Ayanda: Yes, that is why I was explaining to you that we actually had junior laboratories and senior laboratories. In senior laboratories we had biology lab, chemistry lab and physics lab, three of them. The most set up were there because we cannot expect that every school is perfect but most of the schools I can assure you because like I said that we would order materials from South Africa. the equipment, the chemicals. That is why when I came this side, I thought ahhh South Africa is perfect, if we are buying from them then they are number one but I found to be actually opposite.

Researcher 2: you found it to be the opposite of what you thought….

Ayanda: We bought the chemistry laboratory… like I told you that the teacher will just tell the lab assistant that we want to do this experiment and he would lay out everything, we would do it in groups of three-three people. We had a chance for doing it ourselves not the teacher….the teacher and the lab assistant would be walking around to check if we are doing it right, isn't it at first they give us the rules that these chemicals are dangerous, you handle them with care. The moment you step in the laboratory, you make sure you got covered shoes, you have got a lab coat, it was a must in the laboratory, the acid proof one.

Researcher: That was in the public school?

Ayanda: in the public school. Every child we don't enter the laboratory without safety goggles and closed shoes. You make sure the rules are by the door there. They would tell you the acids are dangerous, don't pour water into acids, everything. The lab assistant assembles the equipment for us, even titrations we were doing it alone and you would spend more time in the laboratory if you don't get the results. Even the, what we call qualitative, we are given solutions, this is solution y and this is solution z, then find out what is in solution z or y. Whether there are calcium iron, there are potassium ions, iodides or groups seven ions and so forth, we would discover them through qualitative and quantitative we've categorised chemistry as qualitative and quantitative analysis. And even exam it was involving the practical, and it had a lot of marks, you fail the practical eyyy its bad for you.

Researcher: Okay. So how do you teach physical science? What does the physical science mean to you… like how it is / should be taught, just your perspective. Maybe here in the school or in other schools. How just you understand it?

Ayanda: It's not done right. It's not done properly. Most of the time it is taught theoretical.

Researcher: Theoretical…and there's no practical work?

Ayanda: Practical is If ever they are there, you wouldn't see they are very few. They cannot believe that you can get back our salt from water, they want… even when I taught them last term I told them we can get back these things, ahhhh they said no no no you are lying. But if we can demonstrate it, if we have a Bunsen burner, one time we collect a Bunsen burner, in no time, ten minutes, the water has evaporated they see, they do it now they believe. Up to now they don't believe distillation, if we had a distiller they would see the process happening if they can test the water if we have clean equipment, to see… you saw that guy he said you mean that water doesn't have salt, he doesn't believe it. It's now pure water, water only, the salt has remained in this beaker….

Researcher: So after your high school life, where did you train for teaching?

Ayanda: Look I, (laughing). Initially I did not train as a teacher, I trained let me say as an industrial chemist.

Researcher: That's okay, then….

Ayanda: so after I finished chemistry I went to teach it was one of the… (inaudible). And then I was working for them, mathematical… (interruption and could not capture everything clearly) so I worked there for thirteen years, almost 13 years.

Researcher: Thirteen years, so did you train from Zim (Zimbabwe)?

Ayanda: Yes.

Researcher: And worked there….so when did you start to be a teacher?

Ayanda: Like I said there I taught (inaudible), then when I came to South Africa it was my husband first, my husband initially was a professional teacher trained in Cuba, when things were not going well, economy wise in Zimbabwe, that's when he heard South Africa was looking for maths and science teachers, that's when they approached him, then he came to start…the first school which he worked in and taught in it was a private school and then they told him if you want to go and visit some other person can she come and join you, we want you to stay here with your family, we don't want a situation where you are spending for… initially I resisted because I didn't want to be a teacher, to tell the truth. I didn't want to be a teacher, so I had to come and join, I was now teaching, I also went to enrol with UNISA (University of South Africa) to do PGCE (Postgraduate Certificate in Education)

Researcher: Ohh you did PGCE with UNISA, do you remember maybe when?

Ayanda: Mhhh PGCE in 2012

Researcher: 2012…majoring in physical science?

Ayanda: yes, just the method…

Researcher: Oh, the method because you '*had*' the content already…. That's nice. So what other subjects are you teaching here besides physical science?

Ayanda: I teach mathematical literacy but I can teach pure maths but because here they are people who are only trained for pure maths so they are the ones they give to teach pure maths because they can't teach other subjects.

Researcher: so you teach mathematical literacy in grade..?

Ayanda: Grade 12

Researcher: in grade 12 only? And then Physical Science in grade ten only? How many classes of grade 10 are there?

Ayanda: grade 10 only and there are three classes.

Researcher: Three classes…and for maths lit?

Ayanda: maths lit only one class.

Researcher: so you have four classes.

Ayanda: But at times they do need us in Technology when they can also give us technology and natural science, I can teach natural science……so I am comfortable with anything in line with science and maths.

Researcher: So, last week, we saw the pass rate of the grade tens, so the number of students that wrote, there was one hundred and forty-five and the ones who passed was 34. What do you think maybe could be the reason for this performance; you know only 34 passing from one hundred and forty-five?

Ayanda: The main reason, number one, it's discipline.

Researcher: Discipline…from the learners side, or from the management or from the teachers' side.

Ayanda: From the learners' side but learners we cannot blame the learners, it starts with the management. You know if the management lacks discipline, then it becomes a problem because learners are nervous, they are still young, they need direction. But if you don't give them direction, they also lose direction. So, as a result, they don't have discipline, they are not committed to their school work. As you see them, they don't put any effort and like I told that you give them and they don't do it. Maybe by force, when I checked, I do random checking many learners they don't write and at times even if we report, the principal always say ahhhhh you are teachers you can see what you can do. What should I do as a teacher? And these learners know that teachers mustn't beat us. And you can try any other method of punishment as long as they know that the principal doesn't do anything to us (learners), what more you teacher, they cannot listen to you. So, our main problem, when I look at the situation, it does not mean these learners are incapable they are capable but they lack commitment and the other problem is that, these learners when you check from grade 8, grade 9 they've been failing in these grades but they've been progressed. Now in their minds they know they've been progressed so in their minds they now believe that even if I don't put much effort, even if I fail they are going to push me to the next grade. That is the major cause when you look at last year, the person who passed grade 9 is one (1), who passed without adding marks, adjusting and without progression, it was only one person from grade 9. Now all those learners have been pushed from grade 9 to grade 10, so do you expect something? If they are to tell you the truth, even in the meetings they tell us, remember these learners we adjusted marks, we did one, two, three but and then maths and science teachers we are always against them no what you are doing is wrong, you are now generating a laziness syndrome, they know ukuthi (that) even if they (inaudible) and then they tell you ukuthi (that) what will the community say, if we say all of the learners failed, what will the community say? You understand, they are afraid of the community but they are not afraid of the future of the learners because they are not learning and we always tell them that no you might been pushed but only when you get to grade 12 you cannot be pushed, no one will push you. You will need knowledge, acquire knowledge (inaudible)… if I had another option I would have left teaching long ago (inaudible)… he resigned. You know you end up being sick because you are stressed the situation, we spend much of our time here but when you are stressed, at the end you just leave teaching. If you were to check maths was 26 learners, they were science learners (inaudible) out of 141. Its a serious issue but here we are saying maths and physical science, its an MST (Maths, Science and

Technology) school and when you look at the discipline ya (of) grade 8 and 9, some teachers have got, I cannot blame learners only, even some teachers in the lower grades they know they are not going to be held accountable, they leave learners unattended or they don't do (inaudible).

Researcher: Yeah that's a sad part but in a classroom which language do you usually use to teach physical science? English or ….

Ayanda: Myself I use English. I use English because Xitsonga I am not good with their language, I do understand them when they are talking and I can communicate with the other people when need be but teaching in the Xitsonga I don't want to lie I don't normally do it unless I am just disciplining learners in general but not teaching as in like explaining concepts and then use their language, I cant.

Researcher: So you can say mostly when you teach you just use English..? Maybe you see maybe they are struggling with certain concepts. What do you do to emphasize on those concepts so that they understand them?

Ayanda: What I normally do is, I ask amongst the learners, I know some got it, if he has or she has understood the concept then I ask her or him to explain in their mother language to the other learners.

Researcher: That's really nice. Okay ehmm so maybe, do you think then that the English language that is used, does it maybe shape in anyway the understanding of Physical Science? Maybe does it enable the understanding of science or maybe it limits the understanding of science from the learners side?

Ayanda: From the learners side, I can say that, their English is very bad. It is very bad. The language it does contribute again to the performance of a learner and from their grass root I see it they have not been natured in English quite well. Like when you ask what happened they tell us that previously they were teaching them in their mother language up to grade 3 then from grade 4 maybe they start English which is very wrong. The way I observed even myself at my home, I observed when you teach a child, when is very young, like when is about to go to crèche, you talking to her or to him in English, they get it very fast, very fast. When they very young, I remember when we came this side (South Africa) ehh my son was somewhere in grade 1, was about to go to grade 2 and then he was so much afraid ukuthi (that) how am I going to communicate with these people I don't know their language and we said no you are going to communicate with them in English. Then we just taught him English at home, he got it very fast when he went to school he was now confident, he was very confident. And the other one crèche we also taught him English very fast he got it.

Researcher: Yahhhh, I see. We have a difficult with the language that is used in schools, but I'm not sure what you think about the language. Do you think maybe there's a language specifically that is used in Science, like in teaching Science? The language that maybe is different from the language that is used in Maths, the language that is used in

teaching Geography. Do you think maybe there is any Science specific language, when it comes to concepts and terms, what do you think?

Ayanda: There must be a scientific language. Scientific language in the sense that, for example I have observed when learners write tests or assignments, you find them explaining some concepts in "plain English", you know what I mean by 'plain English', instead of using some scientific terms...

Researcher: So by 'plain English' you mean… just general English…?

Ayanda: Just like they are explaining a story, a general story, you know omitting the English, I mean scientific terms which they are supposed to…like for example if I filtrate a let me say a mixture over there, I expect a learner maybe to use terms like residue, filtrate, and so forth, such terms but they will be using just like ahh (inaudible) will remain in this filter paper and then the liquid will be collected in the beaker. It correct but there are times when you need to use scientific terms filtrate, residue you need to develop scientific knowledge. This is this, this is that and then you explain.

Researcher: So, they do encounter some language difficulties in the assessment?

Ayanda: Yes. I see that because there are times they asked to 'describe' this, you see their answer uses plain English because it will be (inaudible)…you can see more, the learner is supposed to have do so.

Researcher: But then after maybe, you have marked the scripts, maybe you are doing revision, do you maybe highlight those difficulties or challenges with language?

Ayanda: Yes I do

Researcher: You do highlight it. Ohhh okay so do you like explain it to them, to say this means what or … like how do you do it?

Ayanda: How do I do it…..

Researcher: How do you maybe like highlight these challenges with the learners? With the language, maybe what do you want them to do? What do you tell them that they should do?

Ayanda: In most cases I emphasise that they must continually study, they got their textbooks, in a textbook they do use scientific terms, its not plain English, they use scientific terms, I do encourage them to study, the more you study the more it can stay in your memory. But the problem which I noticed, the learners do not study. Even the books if we don't force them to bring them they don't even bring them. You give them the textbooks like the (inaudible) it has a science textbook, initially we made them to share when we expected four classes but now each one has the copy, they are not sharing. But some of them when you force them…some of them never come with textbooks, those who are sharing, no you don't share come with your own textbook, they don't come with it.

Researcher: So given that you have a lot of textbooks and you want them to read more. So do you think that they should know the difference between the Science specific language and just the general English or the plain English that they use? Do you feel that they should know the difference between the two?

Ayanda: Ehheh they should know the difference. When you study, even still when you study, somehow you develop along those lines but if you don't study, and then you can't know. Like I am saying the textbooks are written in scientific language. I mean its English but they need some scientific terms, what we mean we are not saying they must not use English they use English but mix with some scientific terms to show ukuthi (that) we are talking about science as from them just talking about English language, there must be a difference in the English essay and the scientific essay, but if they are the same then we cannot say they are learning science.

Researcher: So, do you explain these terms to the learners during teaching?

Ayanda: I do. Many at times myself I do give them definitions because in the question paper they are also asked to define some terms.

Researcher: That's very nice. So, in the homework that you gave today, you asked the learners to classify, I am not sure what is it that they classifying. I think they classifying physical and chemical change. So, what do you mean when you say, they should classify?

Ayanda: if you are told that when there is lightning the nitrogen in the atmosphere reacts with oxygen in the atmosphere and form nitrogen oxides and then the learner must (inaudible) is it a physical change or it's a chemical change? Now looking at the nature of the process that is…nitrogen is reacting with oxygen now they form nitrogen oxide, these are new products, nitrogen oxides we are now different from nitrogen and oxygen we have new products. So now in the learners mind, in a chemical change, new products are formed, so it means this is a chemical change. And if they said a piece of iron was left outside and then it rusted, the brownish substance was formed which is called iron oxide, again they must know this is a chemical change. There is a reaction that happens between iron and oxygen and then iron oxide is formed.

Researcher: So, by classifying they are like putting, what are they actual doing, they are putting those chemical changes one side and physical changes on the other side?

Ayanda: They can even tabulate and say these are physical changes and these are chemical changes.

Researcher: Ehhhm I think it was last week, you said that sodium reacts with chlorine to achieve or to satisfy the octet rule. I was just interested in understanding what do we mean when we say sodium and chlorine reacts to satisfy the octet rule? I'm not sure, do they know the octet rule?

Ayanda: Yes they know the octet rule

Researcher: And they know sodium and chlorine?

Ayanda: Yes

Researcher: So they know what it means when you say that these two things are reacting and they are satisfying that rule?

Ayanda: The octet rule says an atom can only be stable when it has got eight electrons in its outermost shell. That is at grade 10 level, when it has got eight electrons in the outermost shell. So these group 8 elements are unreactive, that they already have eight electrons in their outermost shell. They don't react they are stable, they satisfy the octet rule, eight angithi (isn't it) the word oct means eight

Researcher: So, you say they are stable, meaning that …

Ayanda: They got eight electrons in their outermost shell that's why they are unreactive

Researcher: Oh, so they are unreactive...

Ayanda: They are unreactive. But other elements group one to group seven they can react because they do not have eight electrons in their outermost shell. Of course with the exception of small atoms like hydrogen, lithium as long as they got two electrons in their outermost shell. But others must eight electrons, the big atoms like sodium and chlorine, sodium because it has one valence electron when it loses, now the remaining shell it that one…. (inaudible)

Researcher: So, the elements in Group one till seven, they are considered reactive can we say that they are stable? It's only the ones of group eight that are unreactive and then they are stable. Just one last more thing. Argon is a noble gas. I just wanted to understand what do you mean by a 'noble', noble gas? The noble part of it. When something is a noble gas, what does that mean?

Ayanda: Myself I…but when I explain it to learners of course you don't get dipper. Why are we saying it's a noble, it's just a special name, according to the grade 10 concepts they are saying they are basic groups of elements which have got special names. Like group one, two…seven, alkali metals, halogens, and noble gases.

Researcher: Do you think it's important to explain what is noble? Don't you think it's important to them, the learners?

Ayanda: To me, I think it depends with the scope of grade 10

Researcher: So maybe you explain it in the following grades? But do you think this explains… (interrupted)

Ayanda: But if maybe there are those learners who would want to know but you can't know them.

Researcher: Oh, they don't ask?

Ayanda: So we just teach them according to the textbook, what they must learn. You know these are special learners because if they may ask why we name it halogens why alkaline? Am I able to (inaudible) nobody has to has to teach something that is not valuable (laughing).

Researcher: I was thinking maybe someone can come with the meaning to say that maybe when they hear some people talking outside the school saying ahhh that person is a noble person. And then now they hear that argon is a noble gas. What does that mean now? Does argon has a good character, like something like that.

Ayanda: It will be just interesting to play around it but (laughing) something beyond their scope. But if they ask then I'll explain to them.

Researcher: If they ask, then you will explain to them.

Researcher: No I see the point. Thank you so much, it was a great three days at your school. Is there anything that you like to ask me?

Ayanda: ehhhh …*inaudible*

Researcher: You can try to convince your colleagues maybe they can do something.

Ayanda: Some challenges according to me is that when we look at the heads of the school. They've politicised the classroom, they've politicised. Things are bad!

Researcher: When did you train again?

Ayanda: PGCE was 2012

Researcher: That's when you finished training?

Researcher: Chemistry was in 1992, finishing?

Ayanda: Yes

Researcher: Eighty-nine is when you started studying?

Researcher: Just teach these kids, impart that good knowledge that you have. When they think about it, they'll realise. Thank you so much for your time.

About 12 years of science teaching. Even though only did PGCE in 2012 but was already teaching even before PGCE.

APPENDIX 4: Sample of Classroom Observation Transcript for Ayanda

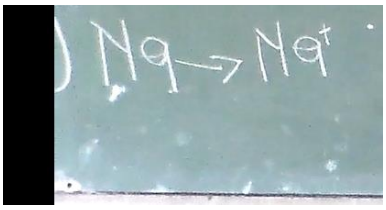
The first observed lesson

The teacher got into the classroom 10 minutes after the period had started.

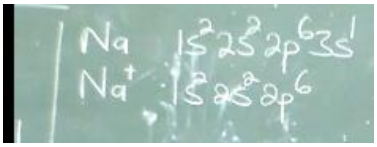
6minutes: "In which group do we find sodium, the element sodium?" learners responding 'group 1'

12:42 – 13:35 minutes: "When sodium forms compound, it usually does so as a positive ion with one unit of charge. What change in electron structure occurs when a sodium atom becomes a sodium ion? 'What change in electron structure occurs' (*emphasis*) remember we did electron configurations, electron configuration that is electron structure or the arrangement of electrons in an atom. So they are saying what change occurs when a sodium atom loses an electron to form an ion, a singly charged positive ion. Maybe do you want to show us on the board, who wants to show us how….(*incomplete*) come and show us.

14:14 minutes: a learner responding to the above question (*change in electron structure*), wrote the following on the chalk board:



14:54 - 15:55 minutes: The question says, please if you can read again the question. The question says…, we on what D? (*Teacher asking learners*) Right D says when sodium forms compounds it usually does so as a positive ion with one unit of charge. What change in electron structure occurs when sodium atom becomes a sodium ion? Remember I wanted to show you here clearly the sodium atom, the structure *(teacher writing on the chalkboard and below is the teacher's writing)*:



Based on the teacher's explanation, Na is the atom and $1S^2$ $2S^2$ $2p^6$ $3S^1$ is the structure of sodium. The meaning of the structure was not explicitly explained in this lesson, as some of these learners might know from life sciences that a 'structure' (cell structure) means that you have to represent the cell diagrammatically showing its nature/structure (how it looks like). But in this lesson (quantum chemistry), electron structure meant electron configuration as the teacher wrote on the chalkboard but never mentioned this to the learners.

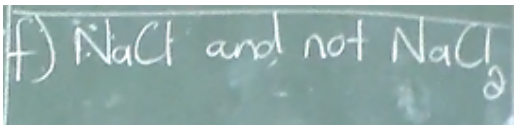
Use chemistry textbooks to differentiates between electron structure (drawing) and electron configurations (derived from the electron structure)

15:55 – 16:36 minutes: remember that first term you learnt that metal atoms react by losing the valence electrons, the few electrons in the outer most shell, which we call the valence electrons. So sodium atom has got one valence electron, so it reacts by losing the single valence electron. You also learnt that the non-metals, they react by accepting electrons.

17:34 – 18:07 minutes: Remember when you learnt about reactions…I mean chemical bonding in the first term, we said it is only the electrons out of the three subatomic particles, its only the electrons that participate in chemical reactions but the protons and neutrons because they are in the nucleus they do not participate in the chemical reactions.

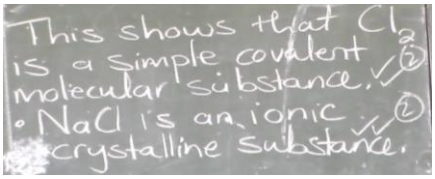
Second video of the first lesson:

02:20 – 03:02 minutes: The formula of sodium is the first one and not the second one because chlorine…sodium and chlorine react in a 1:1 ratio, remember sodium loses one electron and chlorine gains one electron. Group 7 elements that is the halogens, last time you learnt that they react by accepting one electron. You remember the octet rule? (most learners responding and saying yes) when these elements react, they are reacting so that they satisfy the octet rule, each atom must have eight electrons in the outermost shell, you remember that? (*when the teacher was telling this information, she was standing still in front of the class*)



04:52 – 05:09 minutes: we said a compound is a pure substance formed by the reaction of two or more elements in a fixed ratio, in a fixed ratio (*emphasized*).

06:50 – 08:01 minutes: G says chlorine melts at minus 101 degrees Celsius, sodium chloride melts at 801 degrees Celsius. What does this information tell you about the structure of each substance, the structure of each substance? (*Teacher reading the question from the textbook*). Right… in the previous section you were dealing with properties of ionic and covalent substances, properties of ionic and covalent substances. And we said that physical properties like melting point and boiling point they are actually determined by the bonds, the types of bonds in the substances, you remember that…? And we said the stronger the bond the higher….. *(learners: the melting point) the teacher finishing after learners*… the melting point and boiling point. It means that the stronger the bonds, the more energy needed to break the forces, is that so? (*teacher asking learners*). When asked this question learners did not respond and then the teacher after some waiting time she then wrote the answer on the chalkboard.



(teacher's actual writing)

13:45 – 14:14 minutes: Question one, you are given a list of substances there, these substances you must classify them under the subtopics which are given, classify them as atoms, covalent molecular structure, covalent network structure, ionic compounds, metallic, it's supposed to be metallic substances not metallic compounds there, actually it's a mistake *(the teacher 'correcting' the grade 10 physical science textbook). Terms like network should have been explained to the learners so they may know the type of covalent structure but that is networked.*

The second observed lesson

The teacher spends the first five minutes checking learner's homework.

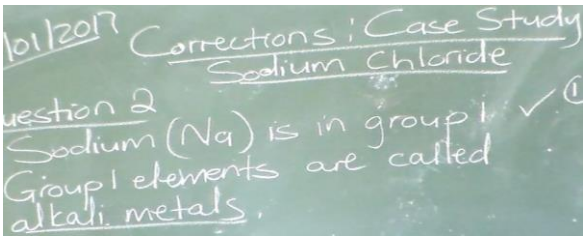
03:11 – 07: 00 minutes: Right on page 151 you are also, we want to the corrections for that case study sodium chloride. Last time I told you that sodium chloride you know, this is a substance which you use every day at home, common salt, table salt, those are some of the names we use for salt isn't it? And this salt is a …(inaudible) it's a compound of sodium and which element….? And chlorine. It's a compound of sodium and chlorine. So in which group do we find sodium?

One Learner responding: group one

Teacher: group one, that's good. Sodium is found in group one. I think yesterday I was a bit disappointed, the fact that sodium, the word SO and then one learner was saying the chemical formula its S. Sodium at this point in time, you learnt about periodic table in first term isn't it? Up to now if you don't know the formula of elements. There are those elements which are very common which we use in our everyday, I mean you should use everyday, you should make sure that you know the symbols, I told you that if you want to learn chemistry easily you need to know the periodic table, study the periodic table, know the elements, know their symbols, know their names, are we together? Especially elements number one up to twenty and then the other common elements which we encounter in our everyday lives, you need to know them by formula and by name and even other compounds which we use in our everyday lives. So now, so sodium is found in group one and what do we call the elements in group one? Elements in group one what are they called? What do we call elements in group one? (no response from learners). Thabo! Group one elements? (no response). You have never heard about the name.

Learners: No!

Teacher: you are serious you were not taught? (learners laughing and the teacher went to the chalkboard to write homework's corrections without giving the name for group one elements).

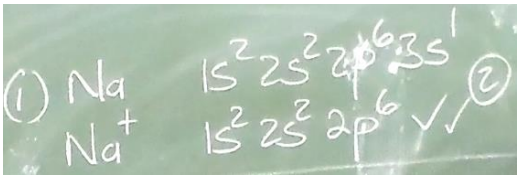


09:22 – 10:08 minutes: right question number B, question number B says how many protons does an atom of sodium have? How many protons, how many protons does an atom…(learners interrupting the teacher) please raise up your hands.

Learner: Twelve

Teacher: they are eleven thank you. Remember on the periodic table sodium is element number eleven and the atomic number tells you about the number of protons in the atom, remember that?

11:18 – 12:59 minutes: Right number B, when sodium forms compounds it usually does so as a positive ion with one unit of charge, with one unit of charge, please make you pay attention and make sure you are learning and understanding. Most of you I know you just copy from other people, you don't even understand one topic. This is time you make sure you understand this because in the exam in the test you will be alone. Right, and then they are saying number one, that is B1, what change in electron structure occurs when sodium atom <u>becomes</u> sodium ion? The electron change, let me…. (teacher writes on the board):



Remember sodium ion is formed by loss of one electron that is the valence electron, valence electron, electron in the outermost shell. So that means that when that electron in the 3S orbital is lost, then we now have a new electron structure in the sodium ion ($2p^6$).

13:26 – 14:45 minutes: Sodium reacts by losing an electron and last term you were also taught that it is the electrons amongst the three subatomic particles. It is the electrons that participate in chemical reactions. That means it is the electrons that move from one atom to another and the neutrons and protons which are in the nucleus, they do not participate in chemical reactions. Are we together? Just a reminder they do not participate in chemical reactions. Only the electrons, these are found in the energy levels, participate in chemical reactions. That you need to remember always, right so D2 says what change if any occurs in the nucleus when the ion is formed? Do we have any change which occurs in the nucleus?

Learner: No

Teacher: the answer is no. Like I just explained that the protons and neutrons which are found in the nucleus, they do not participate in chemical reactions. So they just stay in the nucleus there is no change.

15:17 – 17:14 minutes: E says when chlorine forms an ionic compound it gains one electron. What symbol is used to represent the chloride ion formed in this way? So because it gains one electron so the

chloride ion will give it a Cl minus. So remember I said the size of the charge tells you about number of electrons gained or number of electrons lost. Remember metals react by losing electrons, non-metals react by gaining or sharing electrons, do you still remember that. So the size of the charge, if it is a 2 minus it means it has gained two electrons, if it is a single negative then it has gained one electron, if it 3 minus it has gained three electrons, are we together? So the same applies to CAT ions, cations that is positive ions, if it is a single plus, then it has lost one electron, two plus it has lost two electrons, three plus it has lost three electrons, you understand that? Right and then number F, f says explain why the formula for the compound formed when sodium and chlorine reacts is sodium chloride, 1 to 1 ratio and not 1 to 2 ratio?

18:34 – 19:35 minutes: We also talked about the octet rule, remember the octet rule say that these elements react because they want to satisfy the octet rule and the octet rule says an atom is only stable when it has got eight electrons in the outermost shell, eight electrons in the outermost shell. So sodium when it has lost one electron, the outermost shell now has now eight electrons and chlorine it has seven electrons before it reacts so when it accepts the single electron now it has got eight electrons. Right and then emhhhh G says chlorine melts at minus 101 and sodium chloride melts at 801 degrees Celsius. What does this information tell you about the structure of each substance, the structure of each substance?

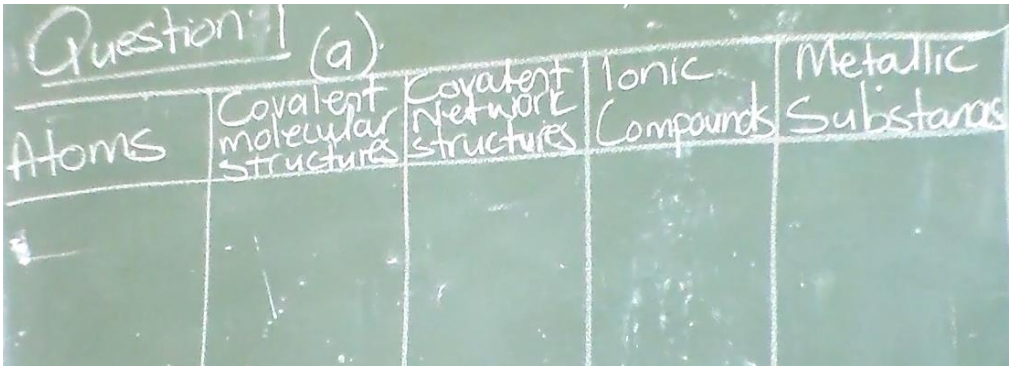
Second video of second lesson

00:07 – 03:26 minutes: In the previous section you were learning about properties of covalent and ionic substances, isn't that so? Ehhhh… (learners: yes). Right so we are saying, physical properties like melting point and boiling point they are actually related to the structure of the substances. So what can you say when you look at these melting points? One is minus 101 is well below zero degrees Celsius. It's a very low temperature that one very very low temperature and then the other one 801 degrees Celsius it's a very high temperature, so what can you say about the structure of the two substances? Lets start with chlorine, chlorine? What is the structure of chlorine? (silence) just tell me what you wrote in your books we will correct it from there, what did you write? What did you write in your books? (silence) *the teacher pointing at learners but no one is responding to her question*. *One learners answers but inaudible*. That's correct, that shows that chlorine is a simple covalent molecular substance, it consists of simple molecules with weak intermolecular forces, remember we said that if the forces between the molecule are weak then it means that less energy is needed to break those forces. Hence the low melting point, are we together? Melting point its about the temperature at which the substance changes from what…from the solid state to the liquid state. So now that it has, I mean it includes… it involves energy. Energy is needed to break forces so that the particles separate. And then we have the substance in the liquid state. *Teacher writing on the chalkboard quietly*.

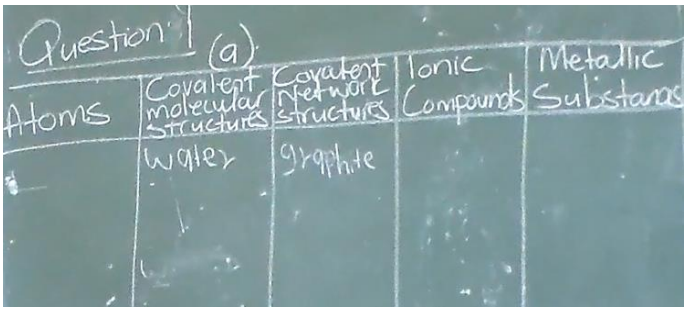
05:28 – 06:08 minutes: But the ionic compounds they've got strong electro forces…electrostatic forces between the ions binding the ions together and then these forces because they are so strong they need more energy to be broken and then… hence the high melting point. So that is about the case study about sodium chloride, sodium chloride what you need to understand is one of those ionic substances and then the other substances you won't a problem with. *Teacher writing on the chalkboard quietly*.

08:21 – 08:42 minutes: Right. You were supposed to draw that table and then you categorize the substances, get writing I'll call some of you to come write these substances under the respective columns. Which one we'll categorize into… (Word pronunciation inaudible).

The teacher drew this table:



Sipho is going to categorize graphite and water, graphite and water, just go and write under the relevant column. Graphite and water, go and write… (learner refusing) why? *(the teacher conversing with the learner)*. Can someone help him, okay can someone him for graphite and water? Any volunteers? *One going to write on the chalkboard and wrote this:*



13: 39 – 14:53 minutes: Right, that is very correct, water consist of four… I mean it has got four valence molecular structure. Water is H_2O, the chemical formula for water is H_2O. those are simple covalent molecules and graphite, graphite is a covalent network it has got covalent network structure, remember the structures on page 148 angithi (isn't it), page 148 you learnt about graphite saying that graphite it consist of carbon atoms which are networked together by covalent bonds. Each covalent atom connected to three neighboring carbon atoms by covalent bonds and then they are actually arranged in hexagonal structures which are then held together by weak Van der Waals forces, are we together? (*yes*) so that is graphite.

15:19 – 16:32 minutes: In which group do we find argon on the periodic table? (learners: group seven) group seven are you sure? Group eight that's correct. Right ehhhm, argon is a noble gas that is found in group eight. It's a noble gas, remember when we were talking about mono atomic elements and di atomic, do you remember that? Mono atomic elements and di atomic elements, mono I said the word mono means what? (learners: one) it means one, so they consist of single atoms, they exist as single atoms. And we said that this is group eight, group eight elements exist as mono atomic elements. So where do you put, I mean on that table where do you write argon? Can someone go and write argon.

18:04 – 20:00 minutes: Remember last time I told you about this, alloys, I said alloys are mixtures, they can be mixtures of metals and other substances like carbon but in most cases its metals which are used to make what alloys. So bronze is also an alloy, its usually a mixture, a mixture of metals so hence it has got what…metallic structure. It goes under the metallic structure or metallic substance on the table. Bronze its an alloy, right lets look at ehhhmm sugar and mercury, okay lets start with sugar, where does sugar fall in that table, sugar how do you categorize it? (*no response*) sugar is made up of three elements which are carbon, hydrogen and oxygen. You start by asking yourself, what kind of elements are these, are they metallic or non-metallic? (learners: non-metallic) They are non-metallic akere (isn't it). Now if they are non-metallic it means now you look at the covalent, the covalent structures there (pointing at the table on the chalkboard) then you now ask yourself could it be covalent molecular or covalent network? Look at the nature of sugar, everyday, most of you, every day you eat sugar at home making the coffee, tea, vetkoek in the what-what you do it with sugar. When you look at sugar, is it covalent molecular? Covalent molecular sugar? (learners: no) its covalent network structure.

Third video of second lesson

00: 06: - 00:30 minutes: When you look outside at the sand, you know that sand angithi (isn't it)? (learners: yes) that sand its silicon oxide, its silicon dioxide so and its also…it consist of crystals, when you look at sand it consist of crystals just like sugar when you look at sugar it also consist of crystals.

00:55 – 01:30 minutes: Okay what is mercury, mercury is it non-metal or metal? It's a what? What is mercury, is it a metal or non-metal? (learners laughing) it's a metal. So where do we put mercury here?

02:08 – 0:19 minutes: what kind of substance is this? Where do we get that one ehhh? Where do you classify this, its an ionic compound. I've always said classifying substance is not complicated, you start by analyzing the substance and then you ask yourself what kind of element is it made up of and then what kind of bonding you find in that substance? If you can answer those substances… I mean those questions then its not difficult to classify or to know the kinds of bonds in the substance….. Remember normal oxygen is O_2 you know that angith (isn't is)? (learners: yes) but ozone is O_3 like that it's a gas, which is found in the atmosphere and this is a very important gas which actually screens UV light from damaging you from substances. Remember UV light is, I mean those are, it's a radiation which is not healthy for us especially when it falls on our skins, it can cause skin cancer. So ozone is important in that it screens that UV light, so the destruction of the ozone layer it actually causes a lot of problems in our lives. So now where do we classify ozone? Where do we put it? Its covalent molecular substance that's correct.

Third observed lesson

This lesson was based on demonstrations; the teacher was demonstrating the physical and chemical changes using school's chemicals and apparatus (demonstration lesson). The teacher began the lesson by showing a video of distillation to learners.

11:09 – 11:40 minutes: Yesterday you learnt that in a chemical change new products are formed but in a physical change there are no new substances formed. Right here I got some few chemicals to demonstrate physical change and chemical change.

12:48 – 16:07 minutes: Remember I said one of the examples of eehhm, one of the examples of physical change if we dissolve salt, this is sodium chloride (showing table salt to learners) sodium chloride the common salt which you eat everyday at home. I am going to dissolve a bit of it in water. So why are we saying this solution of salt and water is a physical change? Why are we saying that it's a physical change? (no response) can someone answer me! (no response) This is salt dissolved in water it forms a salt solution, salt solution. This is one of the homogenous mixtures isn't it? Remember homogenous mixture it has got a uniform composition and uniform colour isn't it? Now you cant even see the salt it has completely dissolved, so we are saying this is one example of a physical change. It's a physical change because it is reversible and also there are no new products formed. The salt remains the same; remember sodium chloride is NaCl the chemical formula of sodium chloride nacl. So it doesn't change whether it is in a solid form or it has been dissolved, it is still sodium chloride, its not reacting with water, there are no new products formed. So we also said that this process is reversible, remember physical changes most of them are reversible, they are reversible, they are easily reversible. Why are we saying they are reversible? We can still get back our water and our salt (learners disagreeing saying NO). Okay now, I don't know why you are not believing it, I don't know the unfortunate thing is we don't have a distiller in our laboratory we are trying to get one, maybe one of these days we will get one. So we are saying we can get back salt and water through distillation or evaporation isn't it? When we evaporate it means that the water will be driven off and disappear in the atmosphere but the salt will remain in this beaker, are we together? Okay, we will try to check whether what we are assaying is right or wrong, its unfortunate that because of all sorts of limitation in this lab we don't have a Bunsen burners but we will try to make use of what we have here. This is a spirit lamp (showing to learners) you've seen it before so the fuel which we are going to use here is the spirit.

16:37 – 16:45 minutes: Right whilst we are waiting for that one lets also look at one of the physical changes.

16:50 – 17:00 minutes: When you were learning about mixtures we said that if you mix iron ***fillings*** and sulphur powder, right iron fillings remember its ***powdered*** iron, greyish in colour (*teacher doing a demonstration*)



Teacher's chemicals used for demonstrations.



T*eacher using magnet to separate iron fillings from sulphur powder*.

Second video of third lesson

00:33 – 02:54 minutes: Even if you take sugar, that I said its salt and water, we can also make use of sugar, I got sugar here. I got a little sugar in this packet, brown sugar, if we also mix it with water you can also get a solution, a sugar solution. Sugar also dissolves in water and the process as I said is the same as that one of salt. You can still reverse them, we have dissolved this sugar, you can use evaporation or distillation to get back the sugar and water. If you use distillation you get both the water and sugar but if you use evaporation the water will evaporate into the atmosphere and you remain with sugar in the beaker, you understand? So we are waiting for our spirit to melt there so that we can see if it can help us to do the evaporation process. Right so those are some of the processes which we said they are actually reversible. We can also take ehhmm… (Teacher interrupted). Right we also said that we can also have mud-water as of those heterogeneous mixtures. If you mix this water and that or a little bit of some soil, you actually get a homogenous mixture. And I said we can also reverse, this process we can reverse it

(teacher is setting up demonstration as she is talking to the learners). Remember we did filtration first term isn't it? What is this one called? (showing a funnel), it's a filter funnel.

04:20 – 05:55 minutes: The teacher was busy looking for some chemicals in the storeroom and left learners with a 'distillation video' to watch. The teacher talks while learners are watching the video:

05:55 – 06:30 minutes: Okay, now this is the distillation process, ehhhh can I have a ruler? Thank you right (teacher re-playing the video)

06:30 – 07:43 minutes: now yes you have a question yes… (learner asking a question in Xitsonga language about the separation of salt and water and the teacher responds in English)

07:44 – 10:55 minutes: This water doesn't have salt at all or … (learners laughing and booing the teacher) right okay okay let me elaborate the process again before I come back to what you are saying. Right so what it means is you make your mixture of salt and water like what we did and then you put in this round-bottom flask, this is a round bottom flask as you can see its round here its not flat. And then it is clamped to this stand here, and this is a tripod stand with a wire gauze here like the one you see there (pointing at a tripod stand in the class). Right this is a tripod stand, a tri means three angithi (isn't it)? And then the wire gauze (showing it) and then this is a stopper and then on this round-bottom flask there is an outlet there where this condenser is connected and then its this delivery tube going inside the condenser and then this one is burner. So as the mixture is being heated it starts boiling remember when its start boiling now the water will change into water vapour, it will come up here then it goes through this condenser and then there is water which is circulating in the water jacket of the condenser, the outside there is water jacket that is circulating around this delivery tube. And then this is a water inlet it gives, it will be connected to the tap and then it get inside here it circulate condensing the steam which is coming from this ehmm round-bottom flask and as it flows through here it is condensed then it goes back to liquid water then it starts to dripping into this beaker here (*teacher talking to the smart board where the video is projected*). So what will be collected here is actually pure water. When we say pure water, its water only not with anything, remember last time I was telling you that tap water is not pure water, it is water mixed with some dissolved salts. Remember this water is actually pumped from the dam or from the river then it is purified there for our own consumption but the purification doesn't remove the dissolved salt, remember as it flows along the river it is dissolving a lot of salt so the tap water has got a lot of dissolved salt including the dust, particles and the likes.

12:03 – 12:25 minutes: Phase changes are what, are all physical changes; that is melting, boiling, evaporation, condensation, freezing, sublimation, deposition, they are all physical changes. Because they are reversible changes.

14:43 – 14:53 minutes: So this copper carbonate if it is heated, it decomposes to copper oxide and carbon dioxide.

18:00 – 18:11minutes: Okay we want to check since you are not believing we cannot get back the sugar by evaporation, lets try to evaporate it in this porcelain dish.

Third video of third lesson

00:03 – 00:20 minutes: I got the potassium iodide; I want to make a solution of potassium iodide its unfortunate that our *test tubes* are not very clean.

01:28 – 01:56minutes: When you are told that this is what other scientists discovered and you don't believe it, you can also do your own experiment and check isn't it? This is why yesterday I told at home I want you to make just aaaa a small amount of…. I mean just take a small amount of salt or sugar dissolve it in water and do the evaporation processes.

03:25 – 04:48 minutes: Okay whilst we are waiting for lead nitrate I want us to look at the reaction between sulphuric acid, sulphuric acid is a very corrosive acid, very dangerous. You need to handle it with care …. Sulphuric acid is very very dangerous you need to handle with care.

5:11 – 05:26minutes: This is lead nitrate, because the water is no pure and also the test tube is dirty that's why you see it forming a white precipitate like this but what I want to show you is look at the colours of these two solutions.



Two test tubes containing lead nitrate and sulphuric acid

05:28 – 05:55 minutes: now if you mix the two (learners surprised of the colour change)



Can you see what we get? You get a green and yellow precipitate, what I want you to understand is this is a chemical change, remember in a chemical change new substances are formed, new substances with different properties from the original reactants, are we together?

07:25 – 07:53 minutes: I want to draw your attention to page ehhm let me just show you the page….check page 155 where they are showing ehhm sugar reacting with sulphuric acid.

08:21 – 08:30 minites: It forms a black substance which is actually is a releasing, I mean it will form carbon and it will also release a gas there.

09:46 – 10:18 minutes: In a chemical change new substances are formed and the opposite is true for physical changes, physical changes are reversible and there are no new substances formed there's only a re-arrangement of particles, are we together? And energy changes in a physical change, there are actually, I mean the energy that is required is very low as compared to the chemical change.

12:11 – 13:23 minutes: On page 179 you are going to answer question number one only, there are questions, I mean there are some processes there which they want you to describe, they describe some processes there. You need to classify them as either chemical change or physical change. Are you listening? You must make sure you write a complete sentence and then at the end you specify whether it's a chemical change or physical change. You don't guess, I want you to reason, remember this is an open book task you can discuss and enquire from other people, you can research, are we together? So research whether there are new substances formed whether the process is reversible and so forth, and then you are now able to classify as chemical change or physical change. This is homework so please make sure by tomorrow's lesson you have written this work and you are done that is page 179 question number one only.

APPENDIX 5: Approval Letter from Mpumalanga Department of Education (larger research project)

APPROVAL TO CONDUCT RESEARCH FOR DR T. NKAMBULE

education
MPUMALANGA PROVINCE
REPUBLIC OF SOUTH AFRICA

Building No. 5, Government Boulevard, Riverside Park, Mpumalanga Province
Private Bag X11341, Mbombela, 1200.
Tel: (013) 766 5533/5118, Toll Free Line: 0800 203 116

Lefapha la Thuto/Isebe, Umnyango wa Punalo | Departement van Onderwys | Nkarabelo ya Dyonalo

Enquiries: A.H. Baloyi
Tel: (013) 766 5478

Dr T. Nkambule
2307 Oasis Security Estate
Cnr Pyp Avenue and Orange rivier Drive
Kempton Park West
1619

RE: APPLICATION TO CONDUCT RESEARCH: DR T. NKAMBULE

Your application to conduct research was received on 25 February 2015. The title of your study is: "Conditions of teaching and learning that facilitate and/or constrain learning in rural high Schools." The research objectives, significance and overall design of your study give an impression that the outcomes of the study will be useful and valuable in improving teaching and learning in rural schools. Your request is approved subject to you observing the content of the departmental research manual which is attached. You are required to discuss with the principals of the sampled schools regarding the approach to your observation and data collection as no disruption of tuition will be allowed. You are also requested to adhere to your University's research ethics as spelt out in your research ethics document.

In terms of the attached manual (2.2. bullet number 4 & 6) data or any research activity can only be conducted after school hours as per appointment. You are also requested to share your findings with the department so that we may consider implementing your findings if that will be in the best interest of the department.

MPUMALANGA
THE PLACE OF THE RISING SUN

APPROVAL TO CONDUCT RESEARCH FOR DR T. NKAMBULE

For more information kindly liaise with the department's research unit @ 013 766 5476 or a.baloyi@education.mpu.gov.za. The department wishes you well in this important project and pledges to give you the necessary support you may need.

APPROVED/NOTAPPROVED:

MRS MQC MHLABANE
HEAD OF DEPARTMENT

07/3/15
DATE

MPUMALANGA
THE PLACE OF THE RISING SUN

APPENDIX 6: Information Letter for Principals

DATE: 31 July 2017

Dear Principal

My name is Sphamandla Innocent Zulu, I am a Masters student in the School of Education at the University of the Witwatersrand. I am doing research on teaching and learning physical sciences, specifically focusing on "**Grade 10 physical science teachers' understanding and use of language during teaching at high schools in rural Acornhoek, Mpumalanga Province**". Science teacher's language is reportedly a challenge to most physical science learners, hence this research study in gaining an insights into how physical science teachers understand and use the science teacher's language during teaching.

My research involves observing grade 10 physical science teachers' lessons on any topic they will be teaching at the time of data collection. A total of three lessons will be observed per teacher and then video recorded. Following the classroom observation, I will have one interview with the observed teacher (s), which will be based on the observed lessons and their general understanding of the nature of science teacher's language. The interviews will take approximately 30 - 45 minutes and will take place after school hours. This interview will be audiotaped and then both video recorded and audiotaped data will be transcribed verbatim and analyzed for the purpose of this research study, and possibly for presentation at a conference and/or published as a general paper in a journal. All three lesson observations will take place during normal teaching time, in normal classrooms without any additional requirements from/to the teacher. Video recording all lessons is necessary to capture teacher's approaches (writing on the chalkboard, learner-learner or teacher-learner interactions), to minimize disturbance of the lessons, and to also observe the lessons observe several times so as to facilitate in-depth analysis of the observed lessons.

The reason why I have chosen your school is because it has a grade 10 physical science class and it is situated in rural Acornhoek, Bushbuckridge. I am interested in finding out how teachers in your school are using their classroom language to enhance understanding of science concepts by their science learners.

I am inviting your school to participate in this research voluntarily and the school is not going to be disadvantaged in any way. The research participants will not be advantaged or disadvantaged in any way. They will be reassured that they can withdraw their permission at any time during this project without any penalty. There are no foreseeable risks in participating in this study. The participants will not be paid for this study. The names of the research participants and identity of the school will be kept confidential at all times and in all academic writing about the study. Your individual privacy will be maintained in all published and written data resulting from the study.

All research data will be destroyed between 3-5 years after completion of the project.

Please let me know if you require any further information. I look forward to your response as soon as is convenient.

Yours sincerely
Sphamandla Innocent Zulu
12 Stiemens street, Cnr Bertha & Stiemens street, Braamfontein, Johannesburg, Gauteng
Cell phone: 078 549 3480
Email: spha.i.zulu@gmail.com

APPENDIX 7: Information Letter for Teachers and Consent Forms

DATE: 31 July 2017

Dear Sir/ Madam

My name is Sphamandla Innocent Zulu and I am a Masters student in the School of Education at the University of the Witwatersrand. I am doing research on teaching and learning physical sciences, specifically focusing on "**Grade 10 physical science teachers' understanding and use of language during teaching at high schools in rural Acornhoek, Mpumalanga Province**". Science teacher's language is reportedly a challenge to most physical science learners, hence this research study in gaining an insights into how you as a teacher understand and use your oral and written science teacher's language to enhance understanding of science concepts.

My research involves observing and videotaping three of your physical science lessons. The videotaped lessons will be analyzed for the purpose of this research study. As such, I wish to observe and videotape three of your physical science lessons on any physical science topic (s) that you will be teaching during data collection process. My research will also involve participating in a 30-45 minutes teacher interview which will be based on the observed lessons and on your general understanding of the nature of science teacher's language. I then wish to interview you after school hours so as to not inconvenience your school teaching hours. This interview will be audiotaped for quality word-to-word conversation. Both video recorded observations and audiotaped interviews will be transcribed verbatim and analyzed for the purpose of this research study, and possibly for presentation at a conference and/or published as a general paper in a journal.

The reason why I have chosen you and your school is because you are a grade 10 physical science teacher who has taught physical science at least for two years. Your school has been chosen because it has a grade 10 physical science class and is situated in rural Acornhoek, Bushbuckridge.

Would you mind if I come to observe (video record) three of your grade 10 physical science lessons and interview (audiotaped) you thereafter all your lesson observations. Your name and identity will be kept confidential at all times and in all academic writing about the study. Your individual privacy will be maintained in all published and written data resulting from the study. All research data will be destroyed between 3-5 years after completion of the project.

You will not be advantaged or disadvantaged in any way. Your participation is voluntary, so you can withdraw your permission at any time during this project without any penalty. There are no foreseeable risks in participating and you will not be paid for this study.

Please let me know if you require any further information.

Thank you very much for your help.

Yours sincerely,
Sphamandla Innocent Zulu
12 Stiemens street, Cnr Bertha & Stiemens Street, Braamfontein, Johannesburg, Gauteng
Cell phone: 0785493480
Email: spha.i.zulu@gmail.com

TEACHER'S CONSENT FORM

Please fill in and return the reply slip below indicating your willingness to be a participant in my voluntary research project called: ***"*Grade 10 physical science teachers' understanding and use of language during teaching at high schools in rural Acornhoek, Mpumalanga Province*"***

I, _____ give my consent for the following:

Permission to observe you in class	**Circle one**
I agree to be observed in class.	YES/NO
Permission to be audiotaped	
I agree to be audiotaped during the interview or observation lesson	YES/NO
I know that the audiotapes will be used for this project only	YES/NO
Permission to be interviewed	
I would like to be interviewed for this study.	YES/NO
I know that I can stop the interview at any time and don't have to answer all the questions asked.	YES/NO
Permission to be videotaped	
I agree to be videotaped in class.	YES/NO
I know that the videotapes will be used for this project only.	YES/NO

Informed Consent

I understand that:

- My name and information will be kept confidential and safe and that my name and the name of my school will not be revealed.
- I do not have to answer every question and can withdraw from the study at any time.
- I can ask not to be audiotaped, photographed and/or videotape
- All the data collected during this study will be destroyed within 3-5 years after completion of this project.

Sign_____ Date_____

APPENDIX 8: Information Letter for Parents and Consent Forms

DATE: 31 July 2017

Dear Parent

My name is Sphamandla I. Zulu and I am a Masters student in the School of Education at the University of the Witwatersrand. I am doing research on "**Grade 10 physical science teachers' understanding and use of language during teaching at high schools in rural Acornhoek, Mpumalanga Province**".

My research involves observing grade 10 physical science lessons, three lessons per teacher in order to find out how science teachers are using science teacher's language to enhance and/or constrain understanding of science concepts. I will Videotape all three observed grade 10 physical science lessons and also make field notes that will be analyzed after the lessons. All lesson observations will be conducted during normal physical science lessons. And the video recorder is used to help me with data that l can observe several times in order to facilitate an in-depth analysis of the lessons observed, and this video recorder will be focused on the teacher.

The reason why I have chosen your child's class is because your child is in grade 10, doing physical science and is taught by the physical science teacher who has agreed to participate in this study. However, your child will not be required to do anything additional rather than being present in his/her physical science lessons as he/she normally does.

Would you mind if go and sit during one of your child's physical science lessons to observe and video record three of their lessons. I will not actively participate in the lessons. Your child will not be advantaged or disadvantaged in any way. S/he will be reassured that s/he can withdraw her/his permission at any time during this project without any penalty. There are no foreseeable risks in participating and your child will not be paid for this study. Your child's name and identity will be kept confidential at all times and in all academic writing about the study. His/her individual privacy will be maintained in all published and written data resulting from this study.

All research data will be destroyed between 3-5 years after completion of the project.

Please let me know if you require any further information.

Thank you very much for your help.

Yours sincerely,

Sphamandla Zulu
12 Stiemens street, Cnr Bertha & Stiemens street, Braamfontein, Johannesburg, Gauteng
Cell phone: 0785493480
Email: spha.i.zulu@gmail.com

PARENT'S CONSENT FORM

Please fill in and return the reply slip below indicating your willingness to allow your child to participate in the research project called: ***"*Grade 10 physical science teachers' understanding and use of language during teaching at high schools in rural Acornhoek, Mpumalanga Province*"***

I, _____ the parent of _____

Permission to observe my child in class	**Circle one**
I agree that my child may be observed in class.	YES/NO

Permission to be videotaped

I agree my child may be videotaped in class.	YES/NO
I know that the videotapes will be used for this project only.	YES/NO

Informed Consent

I understand that:

- My child's name and information will be kept confidential and safe and that my name and the name of my school will not be revealed.
- He/she does not have to answer every question and can withdraw from the study at any time.
- He/she can ask not to be audiotaped, photographed and/or videotaped
- All the data collected during this study will be destroyed within 3-5 years after completion of the project.

Sign_____ Date_____

APPENDIX 9: Information Letter for Learners and Assent Forms

DATE: 31 July 2017

Dear Learner

My name is Sphamandla I. Zulu and I am a Masters student in the School of Education at the University of the Witwatersrand. I am doing research on "**Grade 10 physical science teachers' understanding and use of language during teaching at high schools in rural Acornhoek, Mpumalanga Province**".

My investigation involves observing three of your physical science lessons. The lessons will be video recorded, with the focus on the teacher, and then video recorded lessons will be analysed for the purpose of this research study. As grade 10 learners, you will not be required to do anything rather than being present for your physical science lessons as you normally do. The video recorder will focus on the teacher and it is used to help me with data that l can observe several times in order to facilitate an in-depth analysis of the lesson observations.

Would you mind if I come and sit in your physical science classroom to observe three of your physical science lessons. I will not actively participate in the lessons and these lesson observations will take place during your normal physical science periods. I need your help with your participation during the lesson observations and video recording of the lessons, by being present in the lessons and allowing me to observe your lessons. Remember, this is not a test, it is not for marks and it is voluntary, which means that you don't have to do it and you may choose not to be video recorded. Also, if you decide halfway through that you prefer to stop, this is completely your choice and will not affect you negatively in any way.

I will not be using the video recorded lessons anywhere else except for the purpose of this study, so if you appear in the recorded video, your identity will be protected as your own name will not be used, and your face will be hidden to protect your identity. All information about you will be kept confidential in all my writing about the study. Also, all collected information will be stored safely and destroyed between 3-5 years after I have completed my project.

Your parents have also been given an information sheet and consent form, but at the end of the day it is your decision to join us in the study.

I look forward to working with you!

Please feel free to contact me if you have any questions.

Thank you
Sphamandla Zulu
12 Stiemens street, Cnr Bertha & Stiemens Street, Braamfontein, Johannesburg, Gauteng
Cell phone: 0785493480
Email: spha.i.zulu@gmail.com

LEARNER ASSENT FORM

Please fill in the reply slip below if you agree to participate in my study called: ***"*Grade 10 physical science teachers' understanding and use of language during teaching at high schools in rural Acornhoek, Mpumalanga Province*"***

My name is: _____

Permission to observe you in class	**Circle one**
I agree to be observed in class.	YES/NO

Permission to be videotaped

I agree to be videotaped in class.	YES/NO
I know that the videotapes will be used for this project only.	YES/NO

Informed Consent

I understand that:

- My name and information will be kept confidential and safe and that my name and the name of my school will not be revealed.
- I do not have to answer every question and can withdraw from the study at any time.
- I can ask not to be audiotaped, photographed and/or videotaped
- All the data collected during this study will be destroyed within 3-5 years after completion of this project.

Sign_____ Date_____

APPENDIX 10: Ethics Clearance Letter

Wits School of Education

27 St Andrews Road, Parktown, Johannesburg, 2193 Private Bag 3, Wits
2050, South Africa. Tel: +27 11 717-3064 Fax: +27 11 717-3100 E-mail: enquiries@educ.wits.ac.za
Website: www.wits.ac.za

31 July 2017

Student Number: 700650

Protocol Number: 2017ECE027M

Dear Sphamandla Innocent Zulu

Application for Ethics Clearance: Master of Education

Thank you very much for your ethics application. The Ethics Committee in Education of the Faculty of Humanities, acting on behalf of the Senate has considered your application for ethics clearance for your proposal entitled:

Grade 10 physical science teachers' understanding and use of language during teaching at high schools in rural Acornhoek, Mpumalanga Province

The committee recently met and I am pleased to inform you that **clearance was granted**. However, there were a few small issues which the committee would appreciate you attending to before embarking on your research.

The following comments were made:

- Remove the data collection methods not being used from the consent/assent form

Please use the above protocol number in all correspondence to the relevant research parties (schools, parents, learners etc.) and include it in your research report or project on the title page.

The Protocol Number above should be submitted to the Graduate Studies in Education Committee upon submission of your final research report.

All the best with your research project.

Yours sincerely,

MMaseko

Wits School of Education

011 717-3416

Cc Supervisor: Prof Samuel Oyoo and Dr Thabisile Nkambule

APPENDIX 11: Samples of coded teacher interviews

Oyoo (2016)

Simphiwe: Preparing like making the solution, yah some of them will not understand when we talk about preparation or preparing but then the part of the solution. When we did concentration I specifically said that we are talking about concentration of solutions so we started by going back to term one, the work that we did in term one was talking about solutions different types of solutions the homogeneous the heterogeneous mixtures and stuff so we come back and say when we talk about a solution we talk about when a solute dissolves in a solvent that is a solution. So now when you talking about concentration of a solution we are actually talking about the amount of that solute which will dissolve in that solvent to form that solution, so you see the solution part won't be a problem. Maybe the preparation part but I don't think, maybe ayyh (mixed emotions) some will some won't

Researcher: So some will, some won't…

Simphiwe: They are not the same actually

Researcher: Yah learners understand differently. Was it the first time today you introduced the concept of percentage yield?

Simphiwe: Yes it's for the first time.

Researcher: So given that it was the first time do you think that maybe concepts such as 'actual' and 'theoretical' should have been explained and differentiated?

Simphiwe: Explained neh yah there you are right, there you are right. Cause I just indicated that the actual one is the one that we get, like in reality when you prepare this, this is what you will get. The theoretical one is what you calculate using those stoichiometrical equations

Researcher: So when you talk about theoretical they are not thinking of theory?

Simphiwe: Ehhhh it should be that way. It is theory cause you are actually calculating it theoretically, it is, like it has something to do with theory. Cause you have to use the theory to calculate the …. Its not the actual thing that you are going to get but its actually what the calculations say, what the theory says you must get.

Researcher: So do you think its important to explain those…?

8

Researcher: Ohk how do you do it, do you maybe explain terms or what…?
Thabo: Usually I explain terms then at times I give them some work to go and do based on that. And then when I come to re-mark that work I'll also be highlighting to say this one did not use much of scientific concepts. As we move, you will even hear from themselves comparing their books to say I know you, you use only English not scientific terms.

Researcher: To what extent is the language used in science textbooks, examination papers presents any challenges to your learners?
Thabo: Learners find it difficult because the scientific language used differs with English.

Researcher: Do you think there is a difference between the meanings of commonly used English words and the meaning of the same words in science classroom? For example, the meaning of sensitive (sensitive instruments), spontaneous (spontaneous chemical reactions).
Thabo: Yes

Researcher: Should science learners be aware of this difference? Why or Why not?
Thabo: Yes because if they are not aware they may answer a question incorrectly

Researcher: Do you sometimes use words that are used in general English talks?
Thabo: Yes

Researcher: Do you explain the meaning of these words to your learners?
Thabo: Yes

Researcher: Do you think it is difficult to use science specific language while teaching? Why or Why not?
Thabo: No learners will get used to the scientific language

Researcher: Just to look into the lessons I have observed, let me start with the first one. When you started the lesson you recapped a bit about velocity, you were telling learners that velocity can be constant. So I just want to understand when you were talking of the constant, what is it that you wanted your learners to understand about the velocity being constant.
Thabo: The constant part of it, actually it is constant, scientifically it is uniform

Researcher: Uniform? Meaning that…
Thabo: "That it doesn't increase it doesn't decrease it just move."

Researcher: Ok, so maybe do you know how then English shapes students understanding of Science. Does it help them to understand Physical Science?

Thandi: Mhhhhh! I think it helps the learner because ehhhhhm…. When they further their studies, like doctors and other stuff they said last time that we may try to nurse these children too much but when they go to the outside world, you find that the phrases are just like that. Then to eliminate frustrations, the English that they… from grade 8 to try but to do most of the work in English. Although there and there we emphasise when we see that they are stuck. Then [illegible] tongue so that [illegible] learners.

Researcher: How often does that happen? It's once in a while for some time? Like when you see that they are stuck now.

Thandi: When [illegible] that they are stuck. Mhhhhhh……

Researcher: Okay, okay. Alright no I see, but have you observed any difficulties from your learners which they encountered through the use of English…when learning physical science?

Thandi: Yes. Ehhhh! When you interact with the learners, you can see that they merely capture all what you are saying but in response, like I was… I had a boy which brought these things, I even asked them where do we use copper in our daily lives? She understood what I want and she know the function of copper but he [illegible] in English because I in the [illegible]… ehhhhhm *a re ko mohlagase* (and he says in electricity), mohlagase is electricity.

Researcher: Oh, they can hear, so they can hear you (when using English) but now giving response in this language, they….

Thandi: But they push

Researcher: They push… Okay.

Thandi: [illegible] can. When a learner is giving a wrong answer, I encourage them not to laugh at that learner…(inaudible) improve the learner because its where they can learn correct unlike other subjects they just laugh at you and without even correcting you.

Perspective on English

signify???

Role of Mother tongue

Mother tongue to "simplify" Science

then mother tongue.

given this do they then explicitly explain normal "plain" English words when used in Science contexts?

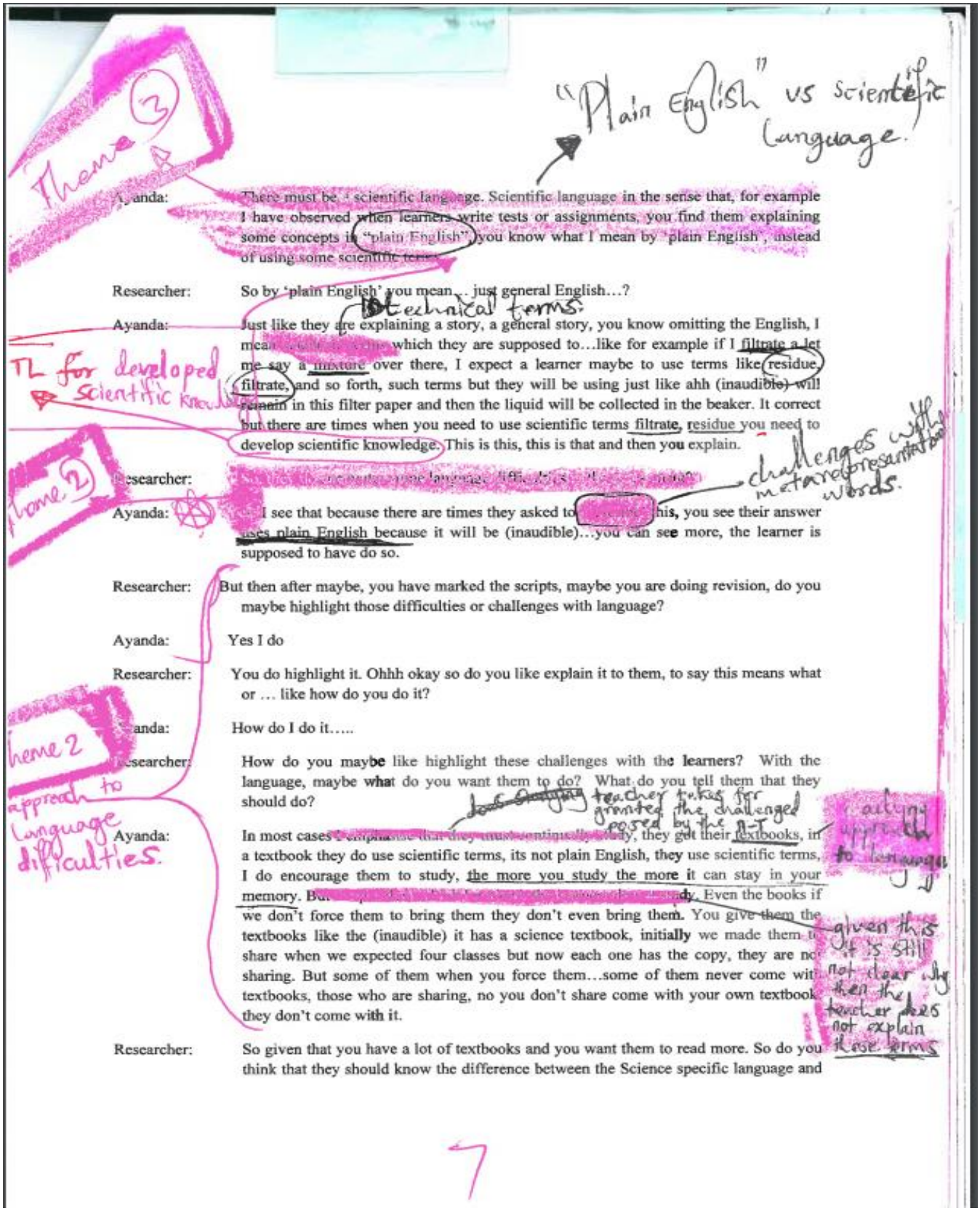
NB

how

how??

which terms??

* Perspectives for difficulties with non-technical words usage.


Theme 3
"Plain English" vs Scientific Language.
Ayanda:
There must be a scientific language. Scientific language in the sense that, for example I have observed when learners write tests or assignments, you find them explaining some concepts in "plain English", you know what I mean by 'plain English', instead of using some scientific terms.
Researcher:
So by 'plain English' you mean... just general English...?
Technical terms:
Ayanda:
Just like they are explaining a story, a general story, you know omitting the English, I mean [illegible] which they are supposed to...like for example if I filtrate a let me say a mixture over there, I expect a learner maybe to use terms like residue, filtrate, and so forth, such terms but they will be using just like ahh (inaudible) will remain in this filter paper and then the liquid will be collected in the beaker. It correct but there are times when you need to use scientific terms filtrate, residue you need to develop scientific knowledge. This is this, this is that and then you explain.
TL for developed Scientific Knowledge
Theme 2
challenges with metaregistral words.
Researcher:
[illegible]
Ayanda:
I see that because there are times they asked to [illegible] this, you see their answer uses plain English because it will be (inaudible)...you can see more, the learner is supposed to have do so.
Researcher:
But then after maybe, you have marked the scripts, maybe you are doing revision, do you maybe highlight those difficulties or challenges with language?
Ayanda:
Yes I do
Researcher:
You do highlight it. Ohhh okay so do you like explain it to them, to say this means what or ... like how do you do it?
Ayanda:
How do I do it.....
Researcher:
How do you maybe like highlight these challenges with the learners? With the language, maybe what do you want them to do? What do you tell them that they should do?
teacher taking for granted the challenged posed by the A-T
Theme 2
approach to Language difficulties.
Ayanda:
In most cases [illegible] they get their textbooks, in a textbook they do use scientific terms, its not plain English, they use scientific terms, I do encourage them to study, the more you study the more it can stay in your memory. But [illegible] dy. Even the books if we don't force them to bring them they don't even bring them. You give them the textbooks like the (inaudible) it has a science textbook, initially we made them t share when we expected four classes but now each one has the copy, they are n sharing. But some of them when you force them...some of them never come wit textbooks, those who are sharing, no you don't share come with your own textbook they don't come with it.
acting approach to language
given this it is still not clear why then the teacher does not explain these terms
Researcher:
So given that you have a lot of textbooks and you want them to read more. So do you think that they should know the difference between the Science specific language and

APPENDIX 12: Samples of coded teacher observations

Second video of second lesson

00:07 – 03:26 minutes: In the previous section you were learning about properties of covalent and ionic substances, isn't that so? Ehhhh... (learners: yes). Right so we are saying, physical properties like melting point and boiling point they are actually related to the structure of the substances. So what can you say when you look at these melting points? One is minus 101 is well below zero degrees Celsius. It's a very low temperature that one very very low temperature and then the other one 801 degrees Celsius it's a very high temperature, so what can you say about the structure of the two substances? Lets start with chlorine, chlorine. What is the structure of chlorine? (silence) just tell me what you wrote in your books we will correct it from there. What did you write? What did you write in your books? (silence) *the teacher pointing at learners but no one is responding to her question. One learners answers but inaudible*. That's correct, that shows that chlorine is a simple covalent molecular substance, it consists of simple molecules with weak intermolecular forces, remember we said that if the forces between the molecule are weak then it means that less energy is needed to break those forces. Hence the low melting point, are we together? Melting point its about the temperature at which the substance changes from what...from the solid state to the liquid state. So now that it has, I mean it includes... it involves energy. Energy is needed to break forces so that the particles separate. And then we have the substance in the liquid state. *Teacher writing on the chalkboard quietly.*

05:28 – 06:08 minutes: But the ionic compounds they've got strong electro forces...electrostatic forces between the ions binding the ions together and then these forces because they are so strong they need more energy to be broken and then... hence the high melting point. So that is about the case study about sodium chloride, sodium chloride what you need to understand is one of those ionic substances and then the other substances you won't a problem with. *Teacher writing on the chalkboard quietly.*

08:21 – 08:42 minutes: Right. You were supposed to draw that table and then you categorize the substances, get writing I'll call some of you to come write these substances under the respective columns. Which one we'll categorize into... (Word pronunciation inaudible).

The teacher drew this table:

Question 1 (a)				
Atoms	Covalent molecular structures	Covalent Network structures	Ionic Compounds	Metallic Substances

Asipho is going to categorize graphite and water, graphite and water, just go and write under the relevant column. Graphite and water, go and write... (learner refusing) why? *(the teacher conversing with the*

Sunshine

Thandi

The first observed lesson

Theme of the lesson: Matter and materials

The teacher had a periodic table in a poster format and put it next to the chalk board to refer to it during the lesson.

01:49 – 03:15 minutes: What do you understand by matter? *Learners responded in a group and they were inaudible to be captured.*

Teacher: Anything that can be able to occupy a space and has mass, when you see that thing is matter from the previous knowledge, from grade 7. Then matter has got its classifications, phases, Thabo *(not learner's real name)* can you give one phase of matter, maybe just to remind you there are three phases of matter….(no response) lets assist Thabo. Yes solid is one phase of matter, solid. Thabo can you give us an example of a solid, its fine take time I will come back to you.

7minutes: *the teacher asked learners to write a formula for water and the following is what learners wrote on the chalkboard*:



10:29 – 11:38 minutes: We have chemical name, chemical name is water (erasing) noo chemical name is not water is hydrogen oxide, its chemical name (pointing at the writing) known as what, we know hydrogen oxide as water, its like most of us here. You've got your name and the name which you are best known of. Now if we say hydrogen oxide, it was going to be easy for you because quickly in your mind you will say there is hydrogen there is oxygen but when I start to say water now you start to say how do I write the chemical formula for water. Water, chemical name is hydrogen oxide.

12:54 – minutes: We've already defined matter, we've got already outlined the phases of matter even the examples as you learnt in the previous grades. What is this matter made of? Now we trying to go deeper but I'm not trying to frighten you, from what you know, now we go one two steps up. What is this matter made of? When we say this chalk *(showing a piece of chalk to learners)* is an example of a solid, which means its matter. What is this chalk made of? When you busy write *(writing with a chalk on a chalkboard)* you can see some particles, there are particles coming out…at the end of the day the chalk is finished. This matter is made of atoms; matter is made of atoms *(repeating)*. What are these atoms? *(teacher responding)* small building block of matter *(teacher writes this on the chalkboard)*. An atom is described as the smallest building blocks of matter. And when atoms are combined, when atoms are combined together they start to form what we call a molecular compound *(learners looked surprise in hearing all these terms "atoms", "molecular compound" but no one asked any question, some learners were laughing among their peers as the teacher turn and writes on the chalkboard)*. It takes us back from what we did in term one when we start to talk about compounds, we cannot have compounds without elements. Let's just quickly remind ourselves the difference between elements and a compound. *This explanation was a one way explanation, where the teacher seems to be the source of all information and*

APPENDIX 13: Sample of a theme development process

