CHAPTER ONE

1.1 Background and Context of the Study

The Department of Basic Education, DBE (2011) clearly states the role of science in general, and physical science in particular. It states that learners who take science (physical science) at grades 10-12 have an improved access to academic courses at Higher Education, professional career paths related to applied sciences and vocational career paths. Science, therefore, plays an important role in the lives of all South Africans due to its influence on scientific and technological development. Scientific and technological development is necessary for the economic and social wellbeing of the population (DBE, 2011). South Africa is in dire need of science related professionals such as doctors, engineers, scientists, science teachers, just to name a few. A good quality of science education at secondary level will probably lead to more learners who qualify to enrol in Higher learning institutions, and this may lead to an improved scientific and economic development.

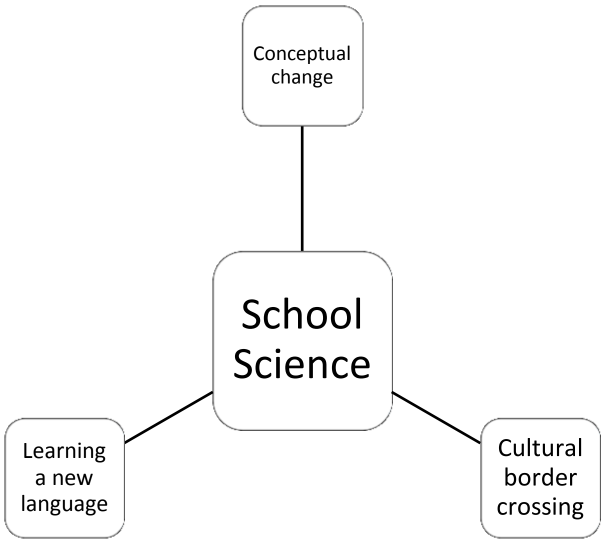
What is science?

Science is a very broad subject and is not easy to give a definition that will include all the aspects of science. According to Feynman (1998, p.5) science can mean a special method of finding out things, a body of knowledge arising from the things found out, or the actual doing of things which he referred to as technology. He also argues that science can be a combination of all the three. Fortje in Oyoo (2014), on the other hand defines science as what society has accepted as worthwhile and scientists have grown to accept as being useful regardless of whether is modern or traditional. Ziman (1987) described science as means of solving problems and also as a body of organised knowledge. It is clear from the three definitions that science can be described, firstly as a special method of studying the world around us, secondly, as body of knowledge which is a result of finding out using special methods, and finally applying this knowledge in the development of technology. According to Lorsbach and Tobin (1992) science is conceptualised as a search for truths, a means of discovering theories, laws and principles associated with reality. However, from a constructivist perspective, science is not real about searching for truths, rather it is a process that helps to make sense of the world around us. From the above definitions, science can be regarded as a way of life. Science can also therefore be regarded as a culture since it has its own ways of doing things which is accepted by the science community. Culture is defined as an ordered system of meaning and symbols in terms of which social interactions take place (Aikenhead, 1996). Science as a culture has its unique language which is different from the everyday language.

Learning Science

One of the challenges associated with science education is to understand what learning science entails. An understanding of what learning of science entails will probably help to address some of the difficulties associated with teaching and learning of science, hence improving the quality of science results at the National Senior Certificate level (NSC). Oyoo (2007) describes learning science, in particular school science in three ways. Learning science involves conceptual change, learning a new language (science), and finally involves cultural border crossing. Oyoo (2007) described this as the plural or triple nature of school science (Figure 1).

Figure 1: The diagram below summarises these aspects of science:



The triple nature of science Oyoo (2007, p.232)

Everyday words acquire new and different meanings when they are used as science words. When they acquire new or different meanings when they are used in science, they, therefore resemble words in new or foreign language (Oyoo, 2007). When these words acquire new or different meanings in science, they represent science concepts. Learning science can be described as conceptual change when learners move from their world view of understanding a particular phenomenon to the scientific view. Aikenhead (1996) argues that learners' understanding of the world view can be regarded as a cultural phenomenon, and learning science as cultural acquisition. Learning science is therefore adapting to scientists' way of doings things, hence learning a new culture. Figure 1 shows the triple nature of science or what Oyoo (2007, p 232) called the 'triadic view of science words'. What it simply means is that firstly, words in science represents new concepts. A word may be used in everyday language, but when it is used in science, it represents a concept. Secondly, words in science represent a subculture which is different from that of learners', and learning science is a process of enculturating learners into the new culture of science, a process called cultural border crossing (Aikenhead, 1996). Lastly, learning science is like learning a new language since words adopt a different meaning from their everyday meanings. For learning science to be effective, teachers should incorporate all the three aspects of school science in their teaching.

Conceptual change has different interpretations in literature. Conceptual change according to Scott, Asoko, Driver, and Emberton (1994) involves coming to terms with new conceptual structures and development of new rationality for knowledge. Taylor (2001) argues that conceptual change involves techniques of accommodation, restructuring, replacing or reorganising a concept. Conceptual change therefore means a change in thinking about a phenomenon after learning has occurred. More often, learners come to the classroom with a world view which is different from the scientific view of the world. If learners emerge with a different view from their original view (prior instructional knowledge) after instruction, then conceptual change will have occurred.

Science has its own language which is different from everyday language. I would imagine that understanding science language will result in effective learning of science concepts. Jarret (1999) argue that that academic language is more abstract than social language, and in science common words can take on specialised meanings. Therefore, words in science should be understood in the context in which they are used. A science learner cannot just look for the meaning of word in the dictionary and assume it is the same meaning in science, but the meaning of words must be understood in their science context. Failure to understand the words in the science context may lead to difficulties in comprehension of science concepts. Hence Wellington and Osborne (2001) argue that the greatest obstacle in learning science, and also the greatest achievement is to learn its language.

School science can be regarded as a culture as Jegede and Aikenhead (1999) argued that science involves the values, ethos, practices and perspectives for interpreting nature. Learning science therefore involves understanding the values, ethos and practices which are accepted in the science community. According to Jegede and Aikenhead (1999) learning science is a social process mediated by the learner's environment, and the pre-instructional knowledge is vital in the construction or reconstruction of knowledge in a new situation. In order for learners to be socialised into the subculture of science, they need more knowledgeable members of that culture or community. In the learning of science context, learners are being assisted to move from their everyday thinking of phenomena into scientific thinking, and this is the cultural border crossing into school science (Jegede and Aikenhead, 1999). Teachers, who are the knowledgeable members of the school science community, use several strategies to help learners to cross the border. In this study, the focus is on the quality of the teachers' language in scaffolding learners or assisting learners to understand science concepts.

The current state of science education in South Africa

South Africa continue to lag behind compared to other countries in terms of mathematics and science education. The Wold Economic Forum (2014) ranked South Africa last out of 148 countries in the quality of mathematics and science. In 2015 there was no improvement as South Africa still ranked last out of 143 countries in the quality of mathematics and science (The World Economic Forum, 2015). Other studies, for example, the Third International Mathematics and Science Study (TMSS), studies by UNCESCO and UNICEF have revealed a poor performance in mathematics and science by South African learners (Mji & Makgatho, 2006). The poor performance in science has been attributed to among other things, lack of basic content on the part of teachers, shortage of qualified science teachers, use of outdated teaching methods, overcrowding, lack of teaching resources, pressure to complete syllabus, heavy teaching loads, inability to manage activities in classroom, poor use of experiments, and inadequate communication ability of both teachers and learners (Howie, 2003; Mji & Makgatho, 2006). South Africa has therefore looked outside its borders in an effort to address the shortage of qualified teachers. Mji and Makgatho (2006) argue that the shortage of science teachers is exacerbated by the fact that few students graduating with mathematics and science choose teaching as a career.

The Department of Basic Education has used various strategies to support science teachers. For example, Sci-Bono discovery centre has been tasked with organising workshops for science and mathematics teachers in Gauteng. In these workshops, teachers are taught the science content, and at times they are examined at the end of the workshop to assess their progress. The purpose of these workshops is to improve the quality of teaching and learning of science and mathematics. Ono and Ferreira (2010) points out that although strategies have been put in place to support teachers, the training of teachers is inadequate as it is characterised by short workshops. The workshops are usually conducted for one or two days by subject advisors who themselves may not have the required expertise (Ono & Ferreira, 2010). There was also the Dinaledi Schools project, which was a part of the National Strategy for Science, Mathematics and Technology to increase the number of learners studying mathematics and physical science in grades 10-12 (Mji & Makgatho, 2006).

The aim of the Dinaledi project was to improve the quality of passes in physical science and mathematics. Some of the strategies used to improve the quality of science and mathematics were as follows: setting performance targets in all schools, hiring qualified and competent teachers, improving the language of teaching and learning, equipping the selected schools with necessary resources and technical support, and introducing ICT in all schools (O'Connell, 2009). One of focus of the project was to improve the language of teaching and learning, but there were no programmes to support this strategy. The Dinaledi schools project has been phased out and is going to be replaced by a programme called MST (Maths, Science and Technology). As a result, the contracts of teachers who were working under the Dinaledi schools project were not renewed for the year 2016. This might be an admission that the project has not achieved the desired results. The Department of Basic Education, through various provincial education departments has also embarked on Secondary Schools Improvement Programmes (SSIP). This is an intervention programme which involves hiring qualified and experienced teachers to teach learners during weekends and holidays. The programme targets mainly underperforming schools and what has been termed priority subjects, of which physical science is one of them.

In spite of all these initiatives, it appears learner performance has not improved. This can be shown by the National Senior Certificate results from 2012 to 2015. In 2012 the percentage of learners who achieved at 40% and above was 39,1%, 42,7% in 2013, 36,9% in 2014, and 36.1% in 2015 (DBE, 2015). Although no percentages were given for those who achieved at 50% and above, it must be shockingly low. These statistics show a decline in the quality of passes in science. The curriculum in South Africa has also undergone changes since 1994, from curriculum 2005 (C2005) which was based on the principle of outcome based education (Jansen & Taylor, 2005) to Revised National Curriculum Statement (RNCS), and there was a move from the RNCS to the National Curriculum Statement (NCS), and finally from NCS to the current Curriculum Assessment Policy Statement (CAPS). These curriculum changes have not yielded any improvement in the quality of passes in science since South is still among the worst performers in science compared to other countries (World Economic Forum, 2015).

As a country, South Africa is in dire need of engineers, scientists, doctors and many sciences related professionals (Mji & Makgatho, 2006). The quality of results indicated above paint a bleak future in science education in South Africa. There is a need to come with solutions which will improve the quality of results. This study highlights that besides the factors mentioned above, the teacher's quality of the science language is vital for quality of science teaching and learning. It also sought to highlight that the teacher's language in the science classroom is not used to transfer facts to learners, but helps learners to construct meaning. Hopefully it will create an awareness that teacher professional development workshops should incorporate language since it is central to conceptual development.

1.2 Rationale

Language is an important tool in concept development, and language in science is not only about proficiency in the language of instruction, but proficiency in the science language (Oyoo, 2008). Language is a tool used to support thinking, as well as used as a stimulant for learners to reflect and explain the world around them (Howe, 1996). Each subject has its own language, and therefore words must be understood in the context of the particular subject, in this case science. Studies elsewhere in the world as well as in South Africa have revealed that learners encounter difficulties with the science language, in particular with everyday words used in science context (Oyoo 2014; Oyoo & Nasimu, 2015). It is important to acknowledge that the teacher as the important resource in the classroom has a role to play in the learners' understanding of the science language. The nature and the difficulty of the science language makes it important to focus on language, particularly the teacher's science language based on the following:

> Teachers convey the ideas of science by trying their best to explain concepts and operations clearly --- make use of metaphors …… demonstrations and practical work to flesh out abstractions …. use projects and discussions for involving students in the subject matter. (Matthews 1998, p.9 in Oyoo, 2012, p.850).

This implies that the quality of the teachers' language during the teaching and learning of science can be regarded as one of the critical factor in the learners' understanding of science concepts. All activities in science including practical work involves language and as result language plays a central role in the teaching and learning of science. The focus on the teacher is also based on the assertion by Edwards and Mercer (1987) cited in Oyoo (2012) that the majority of talk in a lesson is by the teacher. The assertion states that "for about two thirds of time in the classroom someone is talking, about two thirds of this talk is the teacher's, and about two thirds of the teacher's talk consists of lecturing or asking questions" (p.3). The quality of the talk by the teacher is therefore critical to conceptual understanding. The focus on the teacher is based on the premise that science words or everyday words used in science context are difficulty, and the teacher need to pay particular attention to explanation of these words. The difficulty of the science language is discussed in section 2.6 and the role of the teacher in mediating both language and content is discussed in section 2.8. In South Africa studies in the area of the language have mainly focused on the proficiency in the language of instruction, overlooking the proficiency in the science language. This has created a gap in addressing the problems associated with the difficulty of the science language. It is for this reason that this study focused on the language, in particular, the science teachers' language. The science teacher's language in this study refers to both the oral and non-verbal communication by the teacher.

1.3 Research Questions

Although teaching and learning involves interaction between learners and the teacher, and interaction among learners, the focus of this study is on the quality of the teachers' science language in assisting learners to construct new knowledge. The aim of this study is to answer the following research questions:

1. How do teachers make a distinction between everyday language and the science classroom language?
2. When do teachers explain both technical and non-technical words in their science teaching?
3. What factors affect the teacher's effective use of science classroom language when teaching science?

The study also aims to create an awareness of the importance of the quality of teachers' language in science learning.

1.4 Theoretical Framework

This study is underpinned by the constructivist perspective on learning. The constructivist perspective here is based on Piaget's cognitive learning theory and Vygotsky's socio-cultural learning theory. Piaget (1958) views learning as individual activity where learners individual construct their knowledge. Vygotsky on the other hand views learning as an individual activity as well as a social activity. According to Vygotsky's perspective on learning, higher psychological structures such as scientific conceptual knowledge appear first on the interpsychological or the social plane and then inside the child's mind as intrapsychological (Vygotsky, 1978). This process of moving from the interpsychological to the intrapsychological is called the internalisation process, and this process according to Vygotsky (1978) originates in the social plane. The transition from interpsychological to intrapsychological is mediated by language, hence language plays a critical role in the internalisation process. Leach and Scott (2003) contend that the process of internalisation is when individuals are able to process what they encountered on the social plane and use for themselves. In the teaching and learning context, it is when learners can process what they discussed as a class or with the teacher and apply it in different context. In his work, Vygotsky argued that language and thought are interdependent as language is believed to mediate thought, and therefore plays a critical role in concept formation and development (Vygotsky, 1978). If learners understand the science language, it will assist them to construct their own understanding.

1.5 Conceptual framework

This study focussed on the quality of the teacher's science language in assisting learners to construct science knowledge. Language forms the foundation of individual's conceptual ecology as well as the means of conceptual growth (Jones & Brader- Araje, 2002). The importance of language in knowledge construction is also based on the construction of words, knowledge and language as argued by Postman and Weingartner:

> All 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' a way of knowing, and whatever is known is inseparable from the symbols (*mostly words)* in which knowing is codified.
>
> Postman and Weingartner (1971) in Oyoo (2012, p. 854)

This serves as the conceptual framework for this study. This implies that each subject has its language and the words in a particular subject carry meaning which are unique to that subject. Therefore, understanding the meanings of words in the context of that subject is building knowledge in the subject.

1.6 Chapter Summary

In this chapter, the background and context of the study, the current state of science education in South Africa, the rationale for carrying out the study, the research questions and the theoretical and conceptual frameworks which underpin the study were discussed. The chapter briefly discusses the triple nature of science, the performance of learners in physical science over the past four years, and also the intervention strategies that has been put in place to improve the quality of teaching and learning science.

In chapter 2, the role of language in the teaching and learning of Physical Science is discussed. The chapter starts by discussing what learning science entails, followed by the meaning of conceptual change. The components of the science language are also discussed as well as the difficulties associated with the science language. The chapter ends by the discussion of the language in South Africa and the role of the teacher in the teaching and learning of science.

Chapter 3 discusses the research methodology which covers the research design, research methods and research instruments used in the study. The chapter also discusses the sample used in the study and actual data collection process. Research rigour and ethical issues are also discussed in this chapter.

Chapter 4 discusses data presentation, analysis and the findings of the study.

Finally, chapter 5 presents the conclusion, recommendations, limitations and reflection based on this study.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter reviews literature on the role of the teachers' language in the teaching and learning of science. Firstly, what learning science entails is discussed, followed by the components of the classroom language, then the difficulty of the science language, then language in South Africa. Finally, the chapter discusses the role of the teacher in the learning of science, which is the focus of this study.

2.2 What does learning science entail?

Before I discuss what learning science entails, I will start by briefly discussing what science is. From Ziman (1987), science can be defined as "a means of solving problems" (p.1). This definition puts emphasis on the technological aspect of science. The definition puts emphasis on coming up with instruments which can be used to solve real life problems. On the other hand, science is defined as a body of organised knowledge, emphasising information about natural phenomena acquired through research, and organised into coherent theoretical schemes (Ziman, 1987). Finally, science can be viewed in terms in which information is gathered, that is, the methodological aspect of science. Bradford (2015) summarises science as a systematic and logical approach to discovering the world around us, and also the body of knowledge accumulated through the discoveries. Feynman (1998) defined science as a special method of finding out, a body of knowledge arising from the things found out, and the actual doing of things which he referred to as technology. Based on these three authors, science can be viewed as body of knowledge, how that knowledge is gathered and final the application of that knowledge in solving problems.

Teaching and learning science has evolved over the years. The behaviourists approach teaching and learning science in terms of the teacher transferring knowledge to the learner. In this teaching and learning approach, the learner is regarded as a passive recipient of knowledge. Learners are assumed to come to the classroom with no prior or pre- instructional knowledge, and the role of the teacher is to fill the learner with knowledge. This approach promotes neither the interactions between pre-instructional and new knowledge nor conversations that are necessary for internalisation and understanding (Richardson, 1997). This approach which is often referred to as the traditional method of teaching is teacher centred. It does not take into account the needs of the learner (Hassard & Dias, 2009).

However, the thinking of teaching and learning has changed, largely influenced by the constructivist theories. According to the constructivists, knowledge is viewed as something that cannot be transferred from one individual to the other, but constructed by the individual.

Constructivism according to Lorsbach and Tobin (1992, p. 5) is “an epistemology, a theory of knowledge used to explain how we know what we know”. Constructivism define learning in terms of people constructing their own understanding of the world through experiencing things and reflecting on those experiences. According to constructivism, learning is an active process where knowledge is constructed from experience, and learning is regarded as a personal interpretation of the world (Christie, 2005). Constructivism asserts that knowledge resides in individuals and that knowledge cannot be transferred intact from the teacher to the learner (Lorsbach & Tobin, 1992). Rather learners try to make sense of what is taught by trying to fit into what they already know through their experience. The constructivists argue that knowledge is not transferred but constructed and reconstructed by the individual (Richardson, 1997). According to constructivists’ perspective, learners construct new meanings within the context of their current knowledge, previous experience, and social environment. Constructivists argue that learners come to class with some pre –instructional knowledge about the world, and this pre-instructional knowledge is the stepping stone for construction of new knowledge (Lorsbach & Tobin, 1992).

Piaget’s cognitive learning theory, a constructivist theory, view learning as an individual activity which depends on the level of cognitive development (Piaget,1958: 2003). Piaget viewed learning as a process of adjusting to the world using the existing mental structures or schema. He pointed out that this adjustment or adaptation occurs through assimilation, accommodation and equilibration. Assimilation is when one uses the existing schema to deal with new knowledge, an integration of any sort of reality in structure (Piaget, 1958: 2003). Assimilation occurs when a learner perceives new information/objects/events in terms of existing schema. According to Piaget (1958 :2003), accommodation occurs when the existing knowledge does not work and need to be adjusted to deal with new situation or knowledge and as a result there is a need for the existing schemes or operations to be modified to account for a new experience. Equilibration is a process of self-regulation. Equilibration is the driving force for the learning process. Anomalies of experience create a state of disequilibrium which can only be resolved when a more adaptive, more sophisticated mode of thought is adapted (Piaget, 1958:2003). Disequilibrium is thus a result of new knowledge or new information not fitting the existing schema. According to Piaget, learning depends on the stage of development of the child (Piaget, 1964; 2003). Therefore, the science language, hence the science content taught at a particular grade must be appropriate for that level in order for learning to be successful.

Vygotsky (1978) views learning as both an individual and social activity and that knowledge is co-constructed. Vygotsky's socio –cultural learning theory therefore asserts that knowledge development is a process based on human interaction. Lantolf (2003) contend that based on Vygotsky's perspective, knowledge and understandings are constructed when individuals engage socially in talk and activity about shared problems and tasks. Learning is therefore viewed as introducing individuals (learners) to a culture by skilled members of the culture (teachers). Teachers thus play a critical role in socialising learners into the science culture, and will use any strategies at their disposal to enculturate learners successfully. One of the tools used by teachers is language.

Duit and Treagust (2003) argue that the ideas or pre-instructional knowledge that learners bring to classroom can be so deep rooted that they can make it difficult to make learners accept the scientific concepts. More often than not, the learners' pre-instructional concepts are at odds with scientific concepts. In relation to teaching and learning of science, Vygotsky was interested in the relationship between the concepts formed from learner's experience and independent thinking, which he referred to as everyday concepts, to those learned at school, called scientific concepts (Howe, 1996). Learning science thus involves interaction between the everyday concepts and scientific concepts. Oyoo (2012) contend that learning science involves three aspects, namely, conceptual change, cultural border crossing and learning a new language.

2.3 Conceptual Change

The term conceptual change denotes learning science from a constructivist perspective (Duit and Treagust, 2003). These authors identify two types of conceptual change. The first is the weak knowledge restructuring, also referred to as assimilation or conceptual capture, and the second one is the strong or radical knowledge restructuring which involves accommodation or conceptual exchange. The argument put forward by Duit and Treagust (2003) is that during learning, the pre-instructional structures of the learners are restructured so that learners can understand the science concepts. Fellows (1994) views teaching and learning science as realignment in thinking and construction of new ideas that may conflict with earlier ideas (pre-instructional ideas). My understanding of conceptual change is that it is not merely replacing the existing ideas in learners with the scientific concepts or intended knowledge, rather learners must view the new concepts as worthwhile. Hewson (1992) described the learner's existing knowledge as conceptual ecology. Hewson (1992) argues that for learning to occur, there must be interaction between the new ideas and the existing ideas and learning involves changing a person's conceptions in addition to adding new knowledge to what is already there (p.8). Whether learning occurs or not will dependent on the nature of interactions between the new and existing conceptions. Based on Vygostskian framework in Howe (1996), conceptual change occurs when the learner reflects on what he/she has learned at school and by so doing become conscious of things which he/she was not conscious of (p. 39). According to Taylor (2001), conceptual change involves techniques of accommodation, restructuring, replacing or reorganising a concept. Posner, Strike, Hewson, and Gertzog (1982, p.214) and Duit and Treagust (2003, p. 674) cite four conditions for accommodation of scientific conception:

1. Intelligibility

   A conception is intelligible if it makes sense to the learner and is non-contradictory and the learner understands its meaning

2. Plausibility

   The learner must find the conception believable, and there must be consistency in the meaning and application of the concept. It means that the conception must appear to be true to the learner

3. Dissatisfaction with the existing conception

   If competing conceptions, that is, the learner's conception and the new conception do not result in any dissatisfaction, the new conception may be assimilated along the old. However, if there is dissatisfaction or incompatibility between the two conceptions, accommodation will take place, which may also be referred as conceptual exchange.

4. Fruitfulness

   The ability to apply the concept in different situations. This means that having learnt the science concept in class, the learner should be able to apply the concept outside the classroom. The conception should be able to help learners solve problems.

Posner et al (1982) therefore argue that if a new conception is in conflict with the existing conception, the new conception cannot be plausible or fruitful, hence no learning or conceptual change will occur. For learning to take place, the learner must be dissatisfied with the old conception since dissatisfaction with the existing conception will result in restructuring of this conception or exchanging it for the new one. Scott, Asoko and Driver (1991) argue that students cannot adapt to a new conception unless they can represent it to themselves. This implies that learners must find the new conception intelligible.

In the next section, I review the role of language in the teaching and learning of science concepts.

2.4 The role of language

The focus of this study is on the role of language in the learning of science, in particular the quality of the teacher's science. Oyoo (2007, p.103) define language as "a system of sounds, meaning and structure with which we make sense of the world around us". Mammino (2010) described language as a fundamental tool which enables a more detailed, complete and complex communication than any other communication tool. In relation to teaching and learning of science, language plays a vital role since Vygotsky (1978) argued that language and thought are interdependent, as language is believed to mediate thought, whilst on the other hand language requires thought. Vygotsky in Howe (1996) argues that a concept cannot be developed into conscious form without language. This implies that the role of language in conceptual, hence learning, cannot be underestimated. Oyoo (2011) contends that when teachers intervene in learning, they help learners shape their pre-instructional ideas to fit the intended knowledge or science concepts or what is accepted in the scientific community. Lorsbach and Tobin (1992) thus argue that words are not just containers whose meanings are the word itself, but are based on the constructions of individuals. This means that a word on its own has no meaning. The meanings of words depend on the context in which they are used. Nanda and Warms (2011, p. 35) put it correctly when they said "words are symbols, and they stand for things simply because speakers of the language agree that they do".

Language is an important tool in the intervention process, especially how it is used by teachers. Oyoo (2011) rates the teacher's instructional language on the same footing as practical work in terms of helping learners to successful learn science concepts. Personally I would rate language above practical work because any practical work requires language. For learning to be effective learners need not only to be proficient in the language of instruction, but also proficient in the science language (Rollnick, 2000). This means learners must be able to understand the meanings of words in science in the context in which they are used and be able to distinguish everyday meanings of words from the science meanings. Learners must be able to code and decode the language of science (Lemke, 1990). We need, however to understand components of science classroom language before discussing the difficulties associated with the science classroom language. The next section therefore, discusses the components of the science classroom language.

2.5 Components of the science classroom language

The science teachers' classroom language consists of the technical component and the non-technical component.

2.5.1 The technical component

The technical component is made up of science words, also referred to as technical words. These are words with precise meanings or definitions in science and they are also referred to as science concepts or concept words (Oyoo, 2012). These words are specific to a science subject and include such words as *capacitance* in physics, *anion* in chemistry or *chromosome* in biology (Oyoo, 2011). Some of the science words are everyday words but given a specific meaning in science. For example, the word *cell* has a specific meaning in biology, yet it can be used in everyday language to mean something completely different from its science meaning. For example, in everyday language, a *cell* may mean a small room where a prisoner is held. The science words have specific meanings as agreed in international community circles (Oyoo, 2008), and must be understood as such in their use in science. The implication on learning of science is that learners will come to class with an understanding of some words based on their use in the community in which they live, and their understanding might not be what is expected of them in science. Hence learning of science involves a shift from the everyday understanding of the word to its science meaning.

2.5.2 The Non-Technical Component

The non-technical component of the science teachers' language is made of non-technical words. According to (Oyoo, 2011), this component of the language can also be referred to as the medium of classroom instruction. Non- technical words are words that have one or more meanings in everyday language but a different meaning in their science context. This is the component of the language which is used to explain the science concepts or technical words. These are everyday words which must be understood in their science context (Oyoo, 2008). Examples of these words include *negligible*, *random*, and *sensitive*. The non-technical component also consists of the metarepresentational terms and logical connectives. Metarepresentational words are thinking words which include metalinguistic and metacognitive words (Oyoo, 2008). According to Wilson (1999), metalinguistic verbs include words such as *define*, *explain*, *suggest*, whilst on the other hand metacognitive verbs include *calculate, deduce, and predict*. These are words used in test and examinations (Oyoo, 2012). Logical connectives are words or phrases which link sentences, or are links within sentences or between a proposition and a concept (Wilson, 1999). Logical connectives occur frequently in everyday speech, in science textbooks, and in the science teacher's language. Logical connectives include such words as *therefore, in order to, hence, so far, alternatively, in terms* (Wellington & Osborne, 2001, p. 15).

2.6 Difficulty of the science teachers' language

The nature of the teacher's language is such that it is different from learners' and the teachers' everyday language. This difference is often the source of difficulty learners encounter when learning science. The way the science teacher uses the language in a science classroom is thus critical to learners' understanding of science concepts. Oyoo (2015) argue that the difficulty of science words is because learners find them tough or unfamiliar. He further contends that learners become confused when a word means one thing in everyday language, but means something different in science. According to Lemke (1990) the difficulty of science language arises from its specialised nature, and this specialised nature makes science appear impersonal and even inhuman to learners. Research indicates that the difficulties encountered with respect to the science language are irrespective of gender, or whether the learners are first or second language speakers of the language of instruction (Oyoo, 2015).

2.6.1 Difficulty of the technical terms/science words

The main problem with technical words in science is partly of their unfamiliarity. Some of the words in science are only unique to science and they are not used in everyday language. Such words are not familiar to learners and they are abstract. However, some science words are used in everyday language, albeit with a different meaning. Oyoo (2007) contends that the fact that some science words have different meanings from their everyday language, makes it difficult for learners to understand them. Osborne in Henderson and Wellington (1998, p.35), argues that learning of physics is "more akin to the learning of a foreign language than it is to the learning of historical facts". The other difficulty associated with science words is their triple identity nature, that is, a science word is conceptual, cultural and linguistic in nature (Oyoo, 2007). Some science words have found use in everyday language or in other fields outside science, and this create a problem because learners tend to use the everyday meaning of the word in science. Although the difficulty of science words has always been attributed to the difficulty of the science content, Oyoo (2014) argues that the foreignness of science words is also important. Some of the technical words are only used in science, and I believe that such words although new will be relative easy for learners to understand since they only have one meaning. The difficulty of such words will be due to their foreignness.

2.6.2 Difficulty with the non-technical component

The non-technical component (non-technical words in science contexts, metarepresentational and logical connectives) pose their own challenge. Cross-national studies based on the pioneer study of Gardner (1971) have revealed that learners encounter difficulties with the non-technical words when used in science context (Oyoo, 2011; Oyoo 2000, Oyoo, 2004). Prophet and Towse (1999), and Oyoo (2000) carried out studies on non-technical words used in science context using participants from first language speakers of the language of instruction and second language speakers of the language of instruction. Their studies revealed that learners had difficulties in understanding of non-technical words in science context irrespective of their linguistic circumstances or gender. Pickergill and Lock (1991) in their study found that there was no difference between the understanding of non –technical words in science context by males and females. The study by Oyoo (2000) used learners from both first and second language speakers, that is, from United Kingdom and Kenya respectively. Both set of learners had difficulty with non-technical words in science context. All these studies used a multiple choice word test. This proved that proficiency in the language of instruction only is not enough. Learners must also be proficient in the science classroom for better performance in science. The understanding of non-technical or everyday words used in science is crucial in the understanding of science concepts since they are used to explain science words. The everyday words according to Wellington and Osborne (2001) make a higher percentage of the science vocabulary as opposed to technical words which makes a very small percentage. These authors point out that the understanding of non-technical words is poor especially when a word has many meanings or if words sound like or they look alike. Words like *power* and *energy* which are used in everyday language can be difficult to learners when they used in science (Wellington & Osborne, 2001). Therefore, these authors urge teachers to be aware of the difficulties learners encounter with the science language. Teachers must be sensitive of the science language at all times and must take time to explain words in science.

Ali and Ismail (2006) in their study of the understanding of the everyday words used in science context, they used three different classes. They used a science, engineering and arts class. On testing the understanding of everyday words used in science context, they found that the science class had the best performance followed by the engineering class, and the arts class was the least. This difference in performance could be attributed to proficiency in the science language by the science as well as the engineering class. Both the science and engineering were familiar with the words in the context in which they were used.

The studies on the comprehension of non-technical words used in science context have revealed that learners encounter the following difficulties:

> Learners selecting words whose meanings were opposite to those intended. For example, *initial* for *final*, *random* for *ordered.*
>
> Learners also confused words in the same semantic field, for example, isolate for insulate, *detect* for *project.*
>
> Learners confusing sound alike words and look alike words for example, *consistent* with *constituent*, *component* with *opponent*, *proportion* with portion, *accumulate* with *accommodate*
>
> (Oyoo, 2008, p. 109)

The metarepresentational terms' difficulties become evident in science examinations and could be the reason why many science learners do not perform well in examinations. Oyoo (2008), referring to the Kenyan situation, pointed out that one of the reasons for low outcomes in subjects such as chemistry, physics and biology was learners' difficulties with words such as *explain*, *comment*, *describe, define, and distinguish*. Logical connectives can also be a cause of difficulties if appropriate measures by teachers are not taken to assist learners to understand them (Oyoo, 2008). Wellington and Osborne (2001) argue that learners encounter many logical connectives in their textbooks, worksheets and teachers' language which they are not familiar with. South African learners also encounter difficulties with both the metarepresentational and logical connectives according to the Umalusi. The chairperson of Umalusi (the body responsible for monitoring the quality of education in South Africa) Professor John Volmink acknowledged the importance of language when he cited language demands as one of the factors responsible for the drop in the pass rate of 2015 National Senior Certificate results (The Citizen, 2015). He said other factors which contributed to the drop in pass rate included the language proficiency, where candidates experience great difficulty in coping with the language demands (The Citizen, 2015, p.3). The next section discusses the language in South African schools.

2.7 Language in South Africa

In African schools, including South Africa, instruction is given in a foreign language, which in most countries is the language of the former colonial master (Brock-Utne, 2014). The problems associated with learning in most African countries is attributed to linguistic rather than semantics since both the teacher and the learner are not familiar with the language of instruction. This has led to many educationists in Africa advocating for the use of indigenous languages as media of instruction. This overlooks the foreignness of the language of science regardless of whether learners are first or second language speakers (Oyoo, 2014). In South Africa, parents prefer their children to learn in English because English is regarded as the language of the economy as well as global language. It is also the work-place language and parents view learning in English as giving their children more opportunities to break into the competitive world (Department of Basic Education, 2010).

South Africa is a multilingual country with 11 official languages (Probyn, 2005). According to Probyn (2005), nine of these languages are indigenous languages and the other two are former colonial languages of English and Afrikaans. Afrikaans was developed in South Africa from colonial language of Dutch. Most schools in South Africa use mother tongue as a language of instruction in the first three grades and make a transition to English in grade 4 (Probyn, 2005). Like many African countries where learners learn science in the in a second language (usually the language of their colonisers), the majority of South African learners learn science in a second language, either English or Afrikaans. Taylor and Prinsloo (2005) argue that proficiency in the language of learning and teaching is one of the major factors contributing to poor performance at school. This is because learners have to communicate in a language they are not familiar with while learning concepts which are sometimes abstract. Hence, Ferreira (2011) points out that teachers have a difficult task of teaching science in English while the learners are still learning the language. This goes further than just understanding the language of instruction because the language of science is quite different from the everyday language. Therefore, learning English only is not enough as the learners must also come to grip with the science language

This means learners have to cope with learning science concepts and the language of instruction at the same time. There have also been concerns whether learners are meaningfully engaged with the subject matter if they learn science in a language in which they are not proficient (Msimanga & Lelliot, 2014). This affect learning of science concepts despite the argument that learning of science is more than just proficiency in the language of instruction (Oyoo, 2012). Howie in Probyn (2005) argue that the majority of South African learners have difficulty in articulating their open ended answers, and have difficulty in understanding questions. In South Africa and other countries, learners do not learn science in home language (Brock-Utne, 2014). This leads to curriculum designers to judge the appropriateness of the language in which science is taught by considering whether it is the learner's home language or not (Oyoo, 2015). This leads to the overlooking of the importance of understanding the science language in the teaching and learning of science.

The science language in this study refers to the teacher's science classroom language, specifically how the teacher uses the language to help learners understand scientific concepts. The teacher's science classroom language here includes both the technical component, non-technical component of the science language.

2.8 Role of the Teacher

Vygotsky' sociocultural learning places the teacher not as a transmitter of knowledge, but as mediator or facilitator of learning. In mediating learning of science concepts, the teacher makes use of language among other things. While research has shown that the major difficulties of learning science is learning its language, Wellington and Osborne (2001) contend that teachers do not see language in science in the same light. If learning is to be meaningful, teachers must make a conscious effort to teach the science language. Shaw (2002) emphasises that the teacher must mediate both the science content and the science language. Mediation of learning science by the teacher is in line with Vygotsky notion of zone of proximal development (ZPD). The ZPD is the place where the teacher mediates learning by assisting the learner to do or understand what they could not do or understand own their own (Hassard & Dias, 2009). It is "the distance between the level of actual developmental as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978, p.86). Vygotsky's ZPD is supported by Bruner's concept of scaffolding.

Scaffolding involves bridging the gap between actual and potential developmental levels (Puntambekar, 2005). Scaffolding refers to support that is designed to assist learners to perform tasks or form new understandings that they would not be able to do on their own. The support should be temporary as it is designed to assist learners to work independently (Hammond, 2001). The teacher's language is one of the tools that the teacher uses to close the gap between actual performance and potential development. In scaffolding learners in the context of language, teachers should be able to emphasise the relationship between the language and the context in which it is used, and that language varies according to context. Hammond (2001) thus argue that language and literacy in science need to be taught, that is, it must not be assumed that learners will automatically pick up such kind of knowledge.

Scott (1998) bases the role of the teacher on Vygotsky's analysis that views teaching as assisting performance. The teacher assists the learner to a level of performance within the ZPD which the learner would not be capable to do independently. Since Vygotsky emphasises the interdependence of thought and language, it is thus important that the teacher must ensure that learners understand the words used in science, be it technical words or non-technical words used in science context. Therefore, teaching involves assisting learners to do what they would not normal be able to do on their own (Scott, 1998). The teacher must use appropriate science language at a given level of schooling if he/she is to assist learners in understanding concepts.

Moje (1995) argues that classrooms can be considered as speech communities where the teacher can selectively use and impose language as a means of fostering speech community identification. The classroom is made up made of individuals from varying speech communities, and the teacher in the classroom represent the science/academic speech community. It is in this regard that the teachers are supposed to use language in ways that will allow them to maintain the identity with the community they represent, the science community (Moje, 1995). For effective teaching to take place, the teacher must help learners to adopt the language of the science community. In the school situation, teachers help learners to adopt the language of the school science.

Thörne, Gericke and Hagberg (2013) found that the teachers' language can be a source of confusion. For example, they found that the use of the words *anlag* and *gene* in Mendelian genetics were used in such a way that they created conflicting meanings to learners. These words were sometimes used to mean the same thing, and at other times they were used to mean different things. Their study found that the way teachers used the words *anlag* and *gene* created confusion in the exact meaning of these two words. Teachers should therefore be conscious in the way they use technical words in science. The authors suggest that teachers should be explicit in the way they explain closely related words but with different meanings (Thörne, Gericke & Hagberg, 2013).

The assumption is that if learners can understand the science words or everyday words in science context, it will enhance learners' understanding or internalisation of science concepts (Oyoo, 2014). This means that teachers must use the appropriate language for a particular level of schooling, taking into account the background of the learners. Oyoo (2014) suggests that in light of the difficulty of science words or everyday words used in science context, teachers need to pay equal attention to both technical words and non-technical words used in science context.

The learning of science concepts can also be greatly affected by the way the words are pronounced in class. Teachers and learners can assume that they talking about same word, yet they are talking of different words because of unfamiliar pronunciation. Gestures can also play an important role in the teaching learning of science. Cook and Goldin-Meadow (2006) argue that teachers often use gestures during instruction to facilitate learning. Learners are thought to understand concepts better if words are accompanied by gestures, but teachers must ensure that the gestures convey the intended meanings, taking into account that many classrooms have diverse cultures. Gestures may mean different things to different cultures.

The speed at which the teacher talks can also have undesirable outcomes. Oyoo (2014) therefore, suggests that the teacher must be aware of the speed at which he/she talks, the pronunciations of the words and the audibility of the speech. If the teacher is talking too fast, for example, learners might end up not recognising the words and can become a source of difficulty. The confusion of words due to speed of talk and pronunciation has been detected even with pre-university level students (Oyoo, 2014).

Schoerning (2014) in her study with college students found that performance in examinations was improved when science-specific vocabulary was translated into plain English. Some of the translated words were as follows: "*Halophile - salt-loving; Aerobe - oxygen- requiring*, and *Lipid – fat*" (p.308).

Students were found to better understand the science terms when they were translated into plain English. Whilst translation to plain English can enhance understanding of science terms, it has its limitations. Some science words cannot be translated into plain English. Sometimes oversimplification of science words can result in creating confusion to learners or the meaning can be misinterpreted completely.

The simplification of science words was also found to enhance understanding in the study by Muralidhar (1991). In the study, the following question was posed:

"Which one of the following requires a non-aqueous solvent to dissolve it?"

A. *Salt*
B. *Sodium nitrate*
C. *Sugar*
D. *Sulphur*

Muralidhar (1991, p. 254)

The study found that only 34 percent gave the correct response. However, rephrasing the question to *"Which of the following requires a liquid other than water to dissolve it?"* (Muralidhar, 1991, p.254), there was an increase in the percentage of the correct responses from 34 percent to 49 percent. In this study the poor performance when the word *non-aqueous* was used was attributed to the disparity between the language used by the science teacher and the language used and understood by the learners. The rephrased question explains what a non-aqueous solvent is. This emphasises the need for teachers to explain science terms as much as they can.

Henderson and Wellington (1998) emphasise the importance of the teacher's language when they say that the quality of the classroom is bound up with the quality of language. Wellington and Osborne (2001) contend that it is not just about language, but about what teachers do with the language. They argue that what the teachers do with the language will ultimately affect how the learners use the language, and that has a bearing on learning science concepts. The role of the teacher in the teaching and learning of science concepts is to lower the language barrier, making it accessible to learners and not just leaving it take care of itself Vine (1997). Hence Shaw (2002) advises teachers to take cognisant of how to successfully mediate content knowledge and the language of instruction especially to second language learners. They can do this by explicitly explaining both technical words and non-technical words used in science context. This is because as already discussed in section 2.6, learners encounter difficulties with the science language irrespective of whether they are first or second language speakers of the language of instruction. Whilst I agree with Shaw, I will advise teachers to go beyond the language of instruction and to take cognisant of how they use the language of science not only to second language learners, but to all science learners. The lack of explanation of science words and words used in science was found to stem from the belief by teachers that difficulties encountered by learning physics is due the difficulty of the subject rather than the contextual meanings of words when they are used in science context (Oyoo 2011). This belief serves as an indication that many teachers are not aware that learners encounter difficulties with the science language.

2.9 Approach to language problem

Although studies indicate that language in science is one of the barriers to learning science concepts, curriculum designers do not include the strategies that can be used to address the language problem in science. Oyoo (2015) has suggested some approaches that can be used in addressing the language problem in science. Some of the approaches suggested include:

- There must be a new measure which is going to be used to measure whether the language used in science classrooms is appropriate
- Both curriculum developers and teachers take serious consideration of how accessible the meanings of different categories of words are to science learners
- Teachers must become conscious of how words change their meanings in the context of the science classroom
- Teachers will need to explain carefully the meanings of words in science, and their varied meanings.

Oyoo (2015, p. 2)

This means that curriculum developers and teachers should not turn a blind eye to the difficulties learners encounter with words in science.

2.10 Chapter Summary

This chapter discussed what learning science entails, the concept of conceptual change, and the role of language in the teaching and learning of science concepts. This chapter also discussed the components of the science language, the difficulties associated with the science language. Finally, the chapter discussed language in South Africa as well as role of the quality of the teachers' science language in the understanding of science concepts.

In the next chapter, I give detailed discussion of the methodology which includes the research approach and design, the selection of the sample used, the methods and instruments used for data collection and the actual data collection process. The next chapter also discusses ethical issues relevant to this study as well as research rigour.

CHAPTER 3: METHODOLOGY

3.1 Introduction

This is a report of a study that sought to establish the quality of physical science teachers' classroom use of language during teaching. In section 2.6, it was indicated that research findings in other parts of the world and in South Africa have revealed that learners encounter difficulties with the science classroom language, be it technical words or everyday words used in science context. It has also been shown that the language difficulty goes beyond the proficiency in the language of learning and teaching. Learners' proficiency should be in both the language of learning and teaching, and the science classroom language for effective learning of science concepts. Review of research findings discussed in section 2.8 has also suggested that the teacher's use of the science language is critical in the learners' understanding of science concepts. The study therefore sought to create and awareness of the importance of the quality of the teachers' science classroom language and that teachers must try to be as explicit as possible in explaining the science words and everyday words used in science context.

This chapter discusses the overall research approach, methods of data collection, research instruments, sampling approach and the selection of participants. In this chapter, I also discuss the ethical issues associated with the study and research rigour. The actual data collection process as well as the analysis strategy are discussed.

3.2 Research Methodology

In this study, the overall research approach used is the case study. Cohen, Manion and Morrison (2000) describe a case study as an approach in research which deals with people in their real situations, and the purpose of a case study is to have an in depth understanding of the phenomenon under investigation. Nisbert and Watt in Cohen, Manion and Morrison (2000, p. 181) define a case study as a "specific instance that is frequently designed to illustrate a more general principle". A case study can also be a descriptive research that is used to study either individuals, a small group of participants, or group as a whole. Although the generalisability of the findings of a case study is questionable, Punch (2009) argue that the potential generalisability of the findings from a case study depends on the purposes of the case study as well as how the data is analysed. The data collection methods used in a case study can be observations, interviews, collection of samples of writings, just to mention a few. The data in this study was collected by means of observing teachers in their normal teaching time, followed by interviewing teachers whose lessons were observed. The research is qualitative in nature as it sought to investigate the teachers' use of language when teaching science, specifically at the quality of the teacher's language used in teaching and learning of science.

3.3 Qualitative Research

This study used a qualitative research approach. Creswell (2003) describe a qualitative research approach as constructivist as the researcher seeks to establish the meaning of phenomenon either from observation or views of participants. Data collection in a qualitative research is by means of interviews with audiotapes and videotapes, observation of participants in their natural environments, and taking fields notes to complement the recordings. Table 1 below gives a summary of the characteristics of a qualitative research

Table 1: Characteristics of a qualitative research

General Framework	Analytical objectives	Data Format	Flexibility
Seek to explore phenomenon Uses unstructured and semi-structured interviews and unstructured observation	To describe variation To describe and explain relationships To describe individual experiences and their views on a particular phenomenon To describe the group norms	Textual data obtained from Videotapes Audiotapes Field notes	Some aspects of the study are flexible, for example, in interviews, the questions are not fixed but depends on the responses of the participants. The way the participants respond will affect how and which questions researchers ask next

In addition to the characteristics in table 1 above, the types of questions asked in a qualitative research are open ended. This allows the participants to give more information on their responses. Questions asked are fixed, but researchers can ask follow up questions. Therefore, data collection and research questions can be adjusted according to what comes up during the data collection process. According to Creswell (2003), the advantage of a qualitative research approach, especially during interviews is that the researcher can probe participants, and they answer questions in their own words.

The next section discusses the methods of data collection in detail.

3.4 Observation

Cohen, Manion, and Morrison (2000) define observation as way of gathering live data, and observation may be highly structured, semi-structured or unstructured. In structured observation, the researcher or observer must know what he or she is looking for and, this is usually applicable when quantitative information is required (Bertram & Christiansen, 2014). These authors contend that the draw back of a structured observation is that it tends to quantify behaviour rather than explaining it. The structured observation schedule might therefore not give a deeper understanding of why certain behaviour occur. Structured observation may result in the researcher missing out on vital information, especially the perspective of the participants. Structured observation uses pre-prepared observation schedules which have specific categories to look for during the observation (Cohen, Manion & Morrison, 2000). The structured observation schedule is time consuming to prepare, but the data from structured observation is easy to analyse.

Semi-structured observation

A semi-structured observation will have issues to be observed, but the gathering of data involves less pre-determined categories compared to structured observation (Opie, 2004). This means that although there might pre-categories to look for, there is flexibility in semi-structured observation.

Unstructured observation

Unstructured observation does not use an observation schedule with prior determined categories, but data is determined by what is found during the observation process. According to Cohen, Manion and Morrison (2000), unstructured observation can provide a rich description of situation or phenomenon and can lead to generation of hypotheses. In this study an unstructured observation was used as method of collecting data since the study was investigating teachers' use of classroom language, in particular the quality of the teachers' science language. The unstructured observation would allow the researcher to be open minded and capture all the data that would help the researcher to answer the research questions. In this research, the researcher observed physical science teachers during their normal teaching time in their normal setting. The researcher did not have pre-set categories but recorded the lessons using a video tape for later analysis. In addition to audio recordings, field notes were taken. The analysis was based on an analytical framework discussed later in section 3.8.

According Opie (2004, p. 122), there are advantages as well as limitations of using observation as a method of collecting data. Observational research has the following advantages:

> Information about physical environment and about human behaviour can be recorded directly by the researcher.
>
> In a classroom situation non-verbal communication such as movement, facial expression which might give an insight of the phenomenon which is being research can be recorded.
>
> The observer can see a different perspective from the participant
>
> Data from observation can be used to supplement data from other methods of collecting data such interviews.
>
> Opie (2004, p. 122)

The limitations of this method of collecting data though is that:

> People may consciously or unconsciously change their behaviour during the observation process, and this can result in unreliable data
>
> The researcher can be biased hence influence the kind of data collected or the way data is interpreted.
>
> Observation as a method of collecting data can be time consuming, especially the transcribing process and the interpretation.
>
> Opie (2004, p.122)

Observation is therefore intrusive because the presence of the researcher in the classroom changes the dynamics of the situation, hence learners and teachers tend to behave differently, an effect called the Hawthorne Effect (Bertram & Christiansen, 2014). Sometimes the participants can do things to impress the researcher or at times they can be withdrawn if they are afraid to make mistakes in the presence of the researcher.

3.5 Interview

In this study, the interview method was also used to collect data. An interview is the gathering of data through direct verbal interaction between the researcher and the participant (Cohen and Manion, & Morrison, 2000). An interview is therefore a systematic conversation between the researcher and the participant. An interview is not just a casual conversation between the researcher and participant, but a conversation with a specific purpose. The purpose of the interview is to obtain information from the participant which can help to answer the research question. An interview can be structured, semi –structured or unstructured depending on the type of data to be collected or the phenomenon under investigation.

Structured interview

In a structured interview, all participants are asked the same questions with the same wording and sequence (Corbetta, 2003). In this type of interview, the researcher must maintain the same voice or tone when interviewing the participants. The researcher must remain as neutral as possible to avoid influencing participant's responses. Opie (2004) points out that in structured interview, questions are usually short, direct, and pre-set. These questions usually require direct answers, for example, yes or no. Structured interview is usually used in a quantitative research.

Semi-structured interview

A semi-structured interview is more flexible than the structured interview, provides for probing, and participants can elaborate their responses (Opie, 2004). In this type of interview, the researcher can deviate from the pre-set questions, and the wording sequence of the questions can be changed depending on how the participants respond. The questions in the interview schedule are just a guide. The benefits of semi-structured interview according to Key (2002) is the ability to gain rapport and participant's trust. This type of interview also gives a deeper understanding of the phenomenon under study since participants can clarify or elaborate on their responses. Opie (2004) emphasises the importance of careful wording of the questions and good technique of asking questions. The flexibility in questioning in semi-structured interviews can be a limitation since researcher bias can creep in (Opie, 2004).

Unstructured interview

This type of interview is more flexible than both the structured and the semi-structured interviews and the direction of the interview is very unpredictable (Cohen, Manion & Morrison, 2000; Opie, 2004). There is no order in which questions are asked, and takes a more or less conversation form between the researcher and the participant. Although this type of interview can give a lot of information, it can be difficult to analyse. Like semi – structured interview researcher bias can be an issue.

In this study, a face to face semi structured interview with the participant teacher was used to supplement the information obtained during observation. The interview was conducted after lesson observations. This type of interview was preferred because the researcher wanted to get the perspective of the participant teachers on teachers' use of science classroom language, at same the time keeping the interview focused through the use of an interview schedule. By using semi-structured interview, the researcher could probe and ask participants to elaborate on some of their responses. Specifically, the purpose of interviewing teacher participants was to find out whether they explicitly explain both science words and everyday words used in science context when teaching physical science. It was also to find out whether participant teachers were aware that learners encounter difficulties with the science language. The interview also sought to find out whether teacher participants were aware of the difference between everyday language and science language. Semi-structured interview was preferred over unstructured interview because of the nature of the study.

Teacher participants were interviewed individually and the following are examples of questions in the teacher interview schedule:

1. Do learners experience difficulties with the science language?
2. What could be the cause of the difficulty?
3. Is the science language different from the everyday language? If yes, how is it different?

Although, the learners were listed in the ethics application as participants, their participation was their mere presence in the lesson. The focus of the study is on the teacher. It is in this regard that the transcripts are mainly about the teacher participants.

3.6 Sampling of participants

McMillan (1996) defines a sample as a group of elements or a single element from which data is collected. Field (2005) on the hand defines a sample as a smaller but representative collection of units from a population from which data is collected to determine the truths about that population. A researcher has to decide how he/she is going to select the sample, a process called sampling. Sampling according to Johnson and Christensen (2008) is a "process of selecting a portion of the population to represent the entire population" (p. 222). However, there are different types of selecting (sampling) participants for study. Cohen, Manion and Morrison (2000) identifies two main types of sampling, that is, probability or random sampling and non-probability sampling. Probability sampling is divided into simple random sampling, systematic random sampling, stratified random sampling as well cluster sampling. In probability sampling, every unit in a population from which a sample is to be selected stands a chance to be selected.

Non-probability sampling on the other hand refers to a method of sampling where some units of population has no chance of being selected. The selection is based on some assumptions regarding the population of interest, and these assumptions form the criteria for selection. In non-probability sampling, sampling can be convenient or purposeful. According Cohen, Manion and Morrison (2000), convenient sampling involves choosing the nearest individuals, that is, choosing those individuals whom the researcher is easy to access, and based on the availability of those individuals. In this study a convenient sampling was used because firstly, the teachers were working in the same school as the researcher, and secondly these are the teachers who agree to participate in the study. The disadvantage of convenient sampling though is that the findings from such a sample cannot be generalised to the total population because it is not representative enough. McMillan (1996) argue that although findings from a convenient sample cannot be generalised, it is none the less important for the understanding of the relationships that may exist regarding the phenomenon under study.

In this study, the sample consisted of two physical science teachers, one grade 10 teacher (Teacher A) and the other a grade 11 teacher (Teacher B). Both are teachers in public schools in Gauteng and they have vast experience, at least 10 years teaching physical science at Further Education and Training (FET) level. FET here refers to grades 10 – 12. Teacher A, at the time of collecting data had 10 years teaching experience whilst Teacher B had 20 years teaching experience. Teacher A was observed teaching mechanics to grade 10 learners and Teacher B was observed teaching electricity to grade 11 learners. Both are teaching at a secondary school in Alexandra Township, Johannesburg. The teachers were chosen because they are teaching grades 10 and 11. Grades 10 are grade 11 are critical since what is taught in these grades forms the foundation of what is examined in grade 12. Some of the topics taught in grade 10 and 11 are examinable in grade 12. The majority of learners are from poor disadvantage communities mostly in and around Alexandra Township. All the learners are second language learners of the language of instruction (English). The pass rate in physical science in the school ranges between 40% to 60% since 2010. It is important to bear in mind that the percentage includes those learners who got 30% since it is regarded as a pass mark.

The majority of learners who pass physical science obtain between 30% and 50%. The quality of passes is thus not impressive. The average number of learners in a science class is 35.

Teacher A is an expatriate teacher and does not speaker any of the local languages. Teacher B on the other hand is a local teacher who is able to communicate using most the local languages. Both participants in this study are second language speakers of the language of learning and teaching. The topics were not specifically selected because the observation of teachers depended on their availability. Grade 10 and 11 prepare learners for grade 12 which is the final grade at secondary school level. The teachers have been teaching long enough to give a true reflection of what happens in science classroom in terms of language use. The qualifications and teaching experience of participant teachers are given in table 2 below.

Table 2: The following table gives the teachers' details:

Teacher	Gender	Qualification	Teaching Experience
Teacher A	Male	BSc plus a Post Graduate Certificate in Education	10 years
Teacher B	Male	BSc Honours in Science Education (Physical Science)	20 years

3.7 Research Rigour

There are three aspects of research rigour namely reliability, validity and credibility. In qualitative research, validity refers to the honesty and genuineness of the research data, while reliability relates to reproducibility and stability of the data (Anderson, 2010). Wellington in Opie (2004, p. 65) defines reliability as "the extent to which a test, a method or tool gives consistent results across a range of settings, and if used by a range of researchers". It means that if the same methods and instruments are used by different researchers in different similar settings, the findings should be similar. Joppe (2000) defines reliability as the extent to which results are an accurate representation of the total population and whether the study can be reproduced using similar methods and instruments. According to Anderson (2010), research reliability refers to the extent to which the findings are an accurate representation of the phenomenon they are intended to represent. On the other hand, validity refers to the degree to which a method or research instrument measures what it is supposed to measure. To ensure validity in this study, triangulation was used. Triangulation refers to the use of two or more approaches in a research, that is, quantitative and qualitative approach or it may refer to the use of two or more methods of collecting data in research. In this study two methods were used to collect data. Cohen, Manion and Morrison (2000) argue that relying exclusively on one method tends to generate data which are simply artefacts of that particular method. To ensure validity in this study, observation and interview methods were used to collect data in this study.

Guba and Lincoln (2005), emphasise that during observation it is important to identify elements in the observed situation that are relevant to the research problem. It would be important therefore that correct field notes are taken and statements of the participants are correctly reported in the research report. The issue of validity goes beyond data collection process. Validity also involves the claims made in the findings in relation to the data collection process (Opie, 2004). The researcher must not alter the statements by the participants, which implies researcher bias must be eliminated as much as possible. It means in the findings section of the report, the statements attributed to the participants must be a true reflection of what they said. The visit to the class by the researcher can also create problems with validity. As stated in section 3.4, the presence of the researcher can result in participants behaving differently. This means that what they do or say in the presence of the researcher might not be what they do or say when the researcher is not present. In this regard, the data collection might not be a true reflection (Bertram & Christiansen, 2014). The first lesson can give inaccurate data because the participants might not be at ease. However, in the subsequent lessons, the participants become used to the presence of the researcher such that they revert back to their normal behaviour (Bertram & Christiansen, 2014).

3.8 This Study

3.8.1 Gaining Access to the research site (Ethical Considerations)

Conducting research involving people can be tricky because some of the methods used can be intrusive, and can usually cause unintentional damage to the participants (Opie, 2004). The damage is usually emotional as some questions might deal with issues which are personal and which people might not want to talk about. It is for this reason that some ethical considerations were be taken into account when conducting research. Sieber in Opie (2004) contends that “ethics has to do with the application of moral principles to prevent harming or wronging others, to promote the good, to be respectful and to be fair” (p. 25). From this definition, it is clear why researchers need to adhere to ethical requirements of the research. This means the researcher must respect the rights of participants, treating them with honesty and dignity. Ethical considerations apply throughout the research process, from research design, accessing the research population, collecting data procedures, interpreting and analysing data up to the writing of the research report.

The first step taken to ensure that ethical considerations are adhered was to apply for Wits School of Education Clearance. The teachers who agreed to participate in the study work in a public school and to access the participants, I applied to the Gauteng Department of Education (GDE) for permission to conduct research in the school. After obtaining the Wits School of Education clearance letter (appendix A) and GDE approval letter (appendix B), I then proceeded to the research site where both ethics letter from Wits and the GDE approval letter were presented to the principal. The researcher explained the purpose of the research and gave the principal a letter (Appendix C) with the details of the research and assuring the principal that the name of the school will remain anonymous and confidential. Only the researcher and his supervisor will have access to the data. After explaining the details of the research, the principal gave permission (verbally) for the researcher to proceed with the study albeit with permission of the Head of Department (HOD) and teachers concerned. The HOD allowed the researcher to talk the teacher concerned.

The researcher explained in detail the purpose of the research to the potential teacher participants and gave participant information letters (Appendix H) so that they can make informed decisions. The potential participants were told that their participation is voluntary, that they have the right to withdraw at any stage, and that their withdrawal will not be disadvantage them in any way. They were also assured that they would remain anonymous in the actual report writing. Pseudonyms will be used instead of the real names, and data collected would only be accessible to the researcher and the supervisor. The data would be kept under lock and key or password protected. The potential participants were also told that they would not be paid for participating in the report. The researcher also assured the participants that the data collected during observation and during the interviews would remain confidentially. Their HODs and principals cannot access the information collected, hence they would not be disadvantaged in any way. Those teachers who agreed to participate in the research were given consent forms (Appendix I) to sign to officially allow the researcher to observe their lessons, and also to interview them thereafter. The purpose of explaining the study and giving the teacher participant information letters was to enable them to make informed consent. Cohen, Manion and Morrison (2000) contend that informed consent is when individuals agree to take part in a research study after being informed of all the information that is likely to influence their decisions.

Although the focus of this study is on the quality of teachers' science classroom language, learners were participants by virtue of being present in the classroom. Therefore, they also needed to give consent for the researcher to observe the lessons. Since at grade 10 many learners are under the age of 18, their parents' permission was to be sought before collecting data. Learners whose teachers were to be observed were given parents information letters (Appendix F) and parents' consent forms (Appendix G) so that their parents can make informed decisions. Learners were also given the learner participant information letters (Appendix D) and consent forms (Appendix E) to sign after the researcher had explained the purpose of the research in detail. The learners were told that the study is not going to affect their marks and that they are not being assessed. They were informed that they reserve the right to withdraw their participation at any stage of the process, and that they will not be disadvantage should they decide to withdraw. Learners were told that participation is voluntary. This was a difficult part because if other learners had not consented, the researcher was going be in a dilemma, because the learners could not leave the class since this was their normal teaching and learning time. Fortunately, no learner in the observed class refused to take part in the study, and their parents also consented.

After obtaining consent from the teachers, learners and parents, the researcher arranged with the teachers and agreed on times for observing lessons. The lesson observations took place in the classrooms in which the participating teachers normal teach on Mondays from 08:00 to 09:00 and on Thursdays from 10:00 to 11:00 because during these times the researcher had no lessons. Teacher interviews were done individual after school in their offices. However, only Teacher A was interviewed. Teacher B did not owner the interview as per arrangement. When the researcher asked the if the interview could be rescheduled, Teacher B agreed but kept on postponing the interview, and it became clear that he was not willing to take part in the interview. The next section discusses the actual data collection process.

3.8.2 Data Collection

3.8.2.1 Observation

After completing all the access issues, the researcher went to observe lessons of teacher participants on agreed times. A videotape was used to record the lessons. The researcher would find a suitable place to record the lesson in such a way that there was minimal interference with the teaching process. Occasionally the researcher would take some field notes especially if he saw something of interest which is relevant to the study. The purpose of using a video recorder was to be able to capture most of the activities which happened during the lesson. It is not possible to record everything during the lesson by taking notes. Videotaping also allows the researcher to capture non-verbal communication which may be relevant to the study. The researcher can play the video many times so that he can capture the correct information. The researcher did not ask or answer questions during the lesson, but only recorded the lessons with the main focus on the teacher. The lessons were one hour long, double periods of 30 minutes long each. Some sections of the lessons were not recorded, especially when learners were given problems to work individually. The reason for leaving such sections out was because the teacher was not talking, but waited for the learners to finish before discussing the problems. Three lessons were observed per teacher. The focus of the study was on the quality of the teachers' science language, hence the recordings focused on sections of the lesson when the teacher was talking.

3.8.2.2 Teacher interview

The teacher participant interview was done after lesson observation of the participant teacher. Teacher A was interviewed individually in his office. The interview was guided by the teacher interview schedule. The interview was done after school when all learners had gone home so that there was no noise interference. The teacher was asked about the difference between everyday language and science language and how he approaches the science language in their classrooms. Some of the questions were guided by what transpired during the lesson. The interview lasted for 15 minutes. The questions in the teacher interview schedule acted as a guide to keep the researcher focused. The interview with Teacher A went on well as the teacher was willing to answer the questions asked.

3.8.3 Review of Data Collection Process

It was easy for the researcher to gain access to the research site because the researcher works at the school and has good working relationship with principal, science head of department and the teachers. One of the teachers (Teacher A) who agreed to take part in the study was very corporative with both lesson observation and interview sections. The teacher understood very well what goes on in research as he had just completed his masters. So he was more than willing to help the researcher collect data. The second teacher (Teacher B) gave the researcher the opportunity to observe his lessons. However, he kept postponing the interview until the end of term, and as result the researcher could not interview him. Both the principal and the HOD for science felt the study could shed some light into the poor performance of learners in physical science. They felt it was a worthwhile study which could benefit school, and they requested the researcher to share the findings for the benefit of the school.

3.9 Data Analysis

Content analysis was used as method of analysing data in this study. Content analysis according to Webber (1991) involves classifying textual material, reducing it to more relevant, manageable bits of data. Oyoo (2012) contends that content analysis enables a decision to be made about a teacher's preferred use of language during teaching. Therefore, content analysis helps the researcher to make sense of the data collected from participants. It helps the researcher to understand the phenomenon under study in participants' perspectives. The video recordings would be transcribed verbatim and this would help to capture what could not have been captured in the field notes. "Transcription is the process of converting videotape, audiotape recordings or field notes into text data" (Creswell, 2003, p.239). Content can be analysed on two levels namely the basic level and the higher level. The basic level involves describing what was said with no comments as to why and how. The high level content analysis on the other hand gives an interpretative analysis where inferences are made. The approach in this study involved both levels. Quotes were used to support the findings. In this study, the analytical framework for lesson observation is as follows:

Communication approach in the science classroom

Explanation of both technical words and non-technical words used in science context

Differentiation between everyday meanings of words and their meanings in science

Quality and appropriateness of language used in asking questions and giving feedback to learners

The above will be the analysis framework for the data obtained from lesson observations.

The teacher participant interview recording was only for Teacher A who participated in the interview. The teacher participant interview was interpreted based on the research questions, and quotes were drawn from the transcripts and compared to what is in the literature. In addition to the observation, the interview analysis looked at the following concerns:

Teachers' belief about the science classroom language

What teachers think is the best approach to make the science classroom language accessible to learners

Teachers' awareness of the science language as a barrier to learning science concepts

(Adapted from Oyoo, 2011)

The purpose of using the observation method and the interview method in this study was to compare what the teachers claim they do in their teaching and what they actual do during the lessons. By so doing, the researcher believed that he could get a true reflection of the teachers' practice. It is however, important to acknowledge that the presence of the researcher might have played a role in the way the teachers conducted themselves during the lessons (Bertram & Christiansen, 2014). Even in interviews, the teacher might have said what they do not practice just to impress the researcher or portray themselves as doing 'good'. It is in this regarded that there was a need to have findings from lesson observation and findings from the teacher participant interviews.

3.10 Chapter Summary

In this chapter, I have discussed the overall research approach, the research methods and the research instruments used to collect data. I have also discussed the sampling, as well as steps taken to ensure the reliability and validity of the study. The data collection process, the problems encountered as well as how the data was analysed was presented in this chapter. The chapter also gives a review of the data collection process. In the next chapter, I present a detailed account of the findings on both the lesson observation and teacher interviews.

CHAPTER FOUR: DATA ANALYSIS AND DISCUSSION

4.1 Introduction

This study was on the quality of the teachers' science language, in particular the quality of the language used by science teachers to help learners understand science concepts. In section 2.6, it was discussed that the language of science is different from everyday language. This difference between everyday language and science language was sighted as the main source of difficulty for learners. It was also indicated in section 2.8 that the way teachers use language in class could be the source of the difficulties for learners. This study therefore sought to find out how teachers use language of science in their science classrooms to help learners understand science concepts. The study aimed to answer the following research questions:

1. How do teachers make a distinction between everyday language and the science classroom language?
2. When do teachers explain both technical and non-technical words in their science teaching?
3. What factors affect the teacher's effective use of science classroom language when teaching science?

Data obtained from observation of lessons was analysed based on the following analytical framework: 1. Communication approach in science classrooms 2. Teacher's explanation of both technical words and non-technical words used in science context. 3. Differentiation between everyday meanings of words and their meanings in science. 4. Quality and appropriateness of language used in asking questions and giving feedback to learners. Quotes from the teachers' utterances were used to illustrate how the science language was used during teaching and learning of physical science for the two teacher participants in the case of lesson observation, and one teacher participant (Teacher A) in the case of interview. Where inferences were made, they were based on what the teachers had said during the lessons, and this was also based on what is already known in literature. These inferences were also made in line with the research questions.

The data from the interview was also analysed by extracting relevant quotes which helped to answer the above research questions. These quotes were also compared to what is in literature. The videotapes were played over and over so that the transcripts are true reflections of what transpired during both the lesson observations and teacher interview (Teacher A). In the next paragraphs, I present the findings in the study, starting with the findings from lesson observation followed by findings from the teacher interview.

4.2 Data Analysis

4.2.1 Observation

Observing teacher participant lessons was to find out how teachers used the science language in their everyday teaching. I watched and listened to the videotape and also used field notes to select the issues which were relevant to my study. I also watched the videotapes over and over in order to find out if there are any non-verbal communications which could be relevant to my study. In both the observation and interview transcripts, the two teachers were identified as Teacher A and Teacher B so that they remain anonymous and that their information remain confidential as they were promised.

4.2.1.1 Teacher A

Communication approach in science classrooms

The two teachers, Teacher A and Teacher B showed different communication approaches during their lessons. There was very minimal involvement of learners during the lesson by teacher A. Teacher A did not allow learners enough time to think about answers and then respond. There was very little interaction with learners. The teacher would ask a question, and without allowing learners to respond, he would go on to answer the question before learners could answer. This deprived him the opportunity of exploring the pre-instructional knowledge of learners. The pre-instructional knowledge of learners is vital in the learning of new conceptions, and teachers should use pre-instructional knowledge to help learners understand new science knowledge (Oyoo, 2011). The answering of questions by the teacher before the learners could respond is supported by the following excerpts:

Teacher A: What is speed? -------- Speed is a scalar quantity.

Teacher A: vectors have size and magnitude. Scalars are what? – (teacher continues without allowing learners to respond to the question but writes on the board to illustrate the difference) Scalars are quantities with size only.

In first instance, the teacher asked what speed was, and the teacher answered the question himself before the learners could respond. The second extract also shows the teacher answering the question he had asked before the learners could attempt it. In my view this denied the learners the opportunity to develop their science language skills through talking. In the lessons observed, the teacher did most of the talking (Edwards & Mercer, 1987). The communication pattern in this case was mainly one way. The manner in which the teacher responded to some of the learners' answers could have contributed to learners not willing to talk. The tone of the teacher was at times intimidating, and could have made learners to refrain from answering the questions.

Teacher A: What is displacement? What is displacement? What is displacement?

Learner: change in position

Teacher A: Change in position. No

*Teacher A: I said no! (*teacher shouts). *Displacement is distance in a specified direction. Didn't I tell you that? I did. You forget fast.*

The response by the teacher showed an element of anger as he was shouting when he was correcting the learner who responded to the question. This could be the reason why learners were unwilling to respond to questions for fear of being shouted at if the responses were not correct. The manner in which the teacher responded could have deprived learners the opportunity to verbalise their answers, and this could result in learners not mastering the language of science, hence finding the science concepts difficult. At times the teacher would ask a question and randomly ask a learner to answer without giving the learner enough time to process the question. The observation made with regard to Teacher A is that he appeared in a rush. He was rushing through the lesson as he wanted to cover as much content as possible. This was close to the end of term test and the teacher was in hurry to finish the topic as it was one of the topics which was going to be examined. The researcher could understand why the Teacher A tried to hurry through the lesson. He was pressed for time.

Explanation of both technical words and non-technical words in science context

Both teachers attempted to explain some terms during their teaching, and they used various strategies in an attempt to make learners understand these terms. In some instances, the teachers were explicit in explanation of the terms, whereas in other instances, explanations were not very clear.

Teacher A*: What is scalar quantity? Speed is a scalar what? Speed is a scalar quantity. What did we say a scalar quantity is?*

Learner*s: Quantity with a magnitude only*

Teacher A: *Yes, it has a magnitude. If we say magnitude, it has a size. So speed is a scalar quantity because it has size. That is what a scalar quantity is.*

In the above extracts, the teacher is explaining why a quantity is called a scalar quantity. The word scalar is not commonly used in everyday language, hence the teacher explained the word. When the learners responded to the teacher's word by indicating that a scalar quantity is one which has magnitude only, they introduced another term, magnitude, which is not common in everyday language. The teacher acknowledged the answer from the learners and went on to explain the meaning of the word magnitude by indicating that the word magnitude means size.

Teacher A*: …… Remember I said speed is a scalar quantity because it has magnitude only. Velocity is a vector quantity because it has magnitude and direction. If you look at your vehicle or taxi, if you look at the speedometer and is moving very. It is distance over time.*

Although the teacher is explaining the difference between a scalar quantity and a vector quantity, the last two sentences of above extract are not very clear, they may create confusion in learners' understanding of the terms scalar quantity, vector quantity, speed and velocity. Explanations of science terms need to be explicit (Oyoo, 2015). However, the teacher went to use practical examples to explain the terms. For example:

Teacher A: *When I say I travelled 20km east, the direction is eastwards and this is displacement. And when I say I travelled 20km, that is distance.*

The way some of the words or terms or phrases were explained was perhaps too technical which might have left learners still confused about the exact meaning of these words. Examples of such words include vector and force. Especially when teacher A was talking about equal vectors and equal forces, he might have created some confusion with regard to the meanings of these terms. I'm not sure though whether it was a genuine mistake or he did not know the meaning of the term equal forces. The following excepts illustrate how the teacher explained 'equal forces or vectors'.

Teacher A: *Are these vectors ..., are they equal? What do you we mean by equal vectors?*

Learner: *(one learner responds, but inaudible)*

Teacher A: *When we talk of equal, we are talking about what? Size. They are the same, they are equal forces. But their directions are different. They must be equal forces. You know what is called equal? If F_1 is equal to 2N downwards and F_2 is equal to 2N upwards, these forces are equal but their directions are different. Equal forces equal vectors, but different directions. These forces are equal but the directions differ. They are equal vectors in the sense that their magnitude is the same but their direction is different.*

This might have left learners with a wrong conception of 'equal forces' or 'equal vectors' because equal forces or vectors refers to two or more forces with the same magnitude (size) and same direction. But the above excerpt defines equal *vectors or equal forces* as forces with the same magnitude but different direction, which is basically an incorrect explanation of the term *equal forces or vectors*. Explaining the phrase '*frame of reference'*, the teacher became too technical and just read the definition from the textbook, and used the Cartesian plane to try to explain the term '*frame of reference'*. I believe the teacher could have used simply language to explain the term. In the Cartesian plane, the teacher used points to represent forces instead of lines with arrows. He went on to talk about the distance between forces when he was actually referring to the distance between two points. This is what teacher A had to say in relation to the forces and distance between two points.

Teacher A: ……… If you are given these two forces are acting at a position, you can determine their position and also the distance between the two forces. the distance between the two points is a straight line joining the forces.

The above excerpt does not make a distinction between a force and a point. The teacher has used the two words (force and point) as if they mean the same, yet they have different meanings. Such use of language can create confusion in learners and also misunderstanding of science concepts (Thörne et al, 2013).

Teacher A: *Let us quickly look at what they have in the textbook. There is what we call frame of reference. A frame of what? A frame of reference. A frame of reference is a set of reference points which has a set of axes that enables position of an object to be defined.*

Looking at the above except, the definition could have left learners not understanding what a *'frame of reference'* real is. The teacher needed to explain what is meant by '*set of reference points' and 'set of axes*' bearing in mind that he was teaching grade 10 learners who might not know the meaning of the words in the context in which they were used in the definition. The teacher did not explain these terms explicitly despite acknowledging in the interview that learners come to grade 10 with lack basic scientific concepts. The word *reference,* for example, could have been given a different meaning from the intended one since learners could have encountered the word in a context other than science. It was therefore critical for the teacher to explain the word clearly in the context of science. The explanation of the word was rather too abstract for the learners to have clearly understood the meaning of the term.

Teacher A could also have explained the word fundamental explicitly in the context in which it was used.

Teacher A: Yes, charge …. yes, thank you, charge is an example of scalar. The other one is distance. There is what we call fundamental units. Unit of measurement. This is important because every quantity must be measured. Remember what I said? I said quantities are measurable.

In the above excerpt fundamental units were not well explained. Learners might have interpreted *fundamental units* to mean just unit of measurement.

Differentiation between everyday meanings of words and their meanings in science

In both teacher participant lessons, there was no explicit differentiation between everyday meanings of words and their meanings in science context. The teachers were just explaining the words as they are used in science. But some everyday words used in science context were not explained at all. In lessons observed, teachers did not seek the meanings of words as learners understood them from their everyday use. I am of the view that had they sought learners' understanding of some words in their everyday use, they could have explained the words better. There are a number of words which were used during the lessons which have different meanings in their everyday use as compared to their science meanings. This include such words as *force, fundamental, reference, unit etc.* These words needed a clear distinction of their science meanings to their everyday meanings. Studies have shown that learners encounter difficulties with these words when they are used in science context.

Quality and appropriateness of the language used in asking questions and giving back to learners

In some cases, teacher A used the language which was not appropriate for grade 10 leaners. He could have lowered the language level to make science concepts accessible to learners. He could have done this by using pain English where possible (Schoerning, 2014). In particular, when he was explaining the phrase '*frame of reference'*, he became too abstract and too mathematical for learners. I believe the teacher could have simplified the definition. Although the definition was from a grade 10 physical science textbook, it was too complex for learners to comprehend. The following excerpt illustrate this:

Teacher A: Let us look at what they have in the textbook. there is what we call a frame of reference. A frame of what? A frame of reference. A frame of reference is a set reference points which has a set of axes that enables a position of an object to be defined (reading the definition from the textbook). For example, F_1 has a frame of reference ($x_{1:}$ $y_{1)}$ and F_2 has a frame of reference ($x_{2:}$ $y_{2)}$. The frame of reference must be determined x and y.

This kind of language is too abstract for grade 10 learners, and it is not appropriate for the comprehension of science concepts. The teacher could have used practical examples to illustrate the meaning of ‘frame of reference’.

4.2.1.2 Teacher B

Communication approach in the science classroom

Teacher B was observed teaching grade 11, and the topic was electricity. This topic, according to the current CAPS physical science curriculum is also covered in in the grade 10 syllabus. Grade 11 work is building on what was covered in grade 10.

Teacher B’s communication approach was different from that of Teacher A. Teacher B encouraged learners to speak, and tried to involve the learners as much as possible. The communication was two - way, although the response by learners was mainly in terms of short answers. If a learner gave an answer which was not clear, the teacher would probe for explanation from other learners. This probing was perhaps an attempt to find out what the learner’s conception was so that he could use that knowledge to enhance understanding. For example:

Teacher B: Let’s speak up guys. Let’s not be shy. It doesn’t matter whether you make a mistake. Remember I always say eee we learn by making mistakes.

Learners here are encouraged to speak and not be too concerned about whether they are going to make mistakes or not. Therefore, in this lesson, there was a high learner participation.

Teacher B: eyy …., can you explain that to me (**the teacher wanted the learner to explain the meaning of indirectly proportional)**

Teacher B: Can you start from here (pointing at the two resistors connected in parallel). You can start from let’s see. You can add the current for 2 and 3 and then you get the current for this …. Ok. So who can elaborate on that yee? Who can add to that, to what she said?

These two excerpts above indicate that the teacher wanted learners to verbalise their answers. The teacher asked questions and allowed learners to respond. If the learner gave an incorrect answer or an answer which was not clear, the teacher was not quick to give the answer, but involved other learners to explain before he could give the correct answer. Although the lessons by Teacher B mainly involve practical work, the teacher was not only showing the learners the results, but allowed learners talk about the results. This indicate that language is also important in practical work (Oyoo, 2012).

Explanation of both technical words and non-technical words in science context

The non-explanation of some non-technical words in science context by Teacher B (grade 11 teacher) perhaps stems from the assumption that they have done these words in lower grades such as grades 8, 9 or 10. This could not be ascertained through interview because Teacher B never gave the researcher the chance to interview him. Although some terms were explained, there are others which perhaps needed some explanation. Let's consider, for example, the following excepts:

Teacher B: *Right, can we proceed. He said eee, the current passing through resistor is directly proportional the voltage across the resistor provided the temperature of the resistor remains constant. Right in such a case, we say the resistor is ohmic resistor. Why ohmic? Because it obeys ohm's law. Right, which resistor is ohmic? Is the one that obeys ohm's law. In other words, we mean to say, eeh, the value of the resistance remains constant. Right. What can change the value of the resistance is temperature.*

The word ohmic was explained by the teacher by indicating to the learners that the resistance of an ohmic resistor remains constant. However, the word resistance was not explained. If learners did not understand the meaning of the word *resistance* in the science context, then it would have affected their understanding of the term ohmic *resistor*. This word *resistance* is used in everyday language and does not have the same meaning to when it is used in science. In science it has a precise meaning which needed to be brought to the attention of the learner. Probably it was explained in earlier lessons or the assumption was that learners know the meaning of the word from grade 10, and this could not be established as Teacher B was never interviewed. It is important to note though that the term *'directly proportional'* is also covered in grade 10 syllabus, but the teacher engaged the learners to ensure that they understood it's meaning even though it might not have been their first time to encounter this term. The term directly proportional is also covered in mathematics at grade 8 and 9. The teacher used the values obtained in the experiment to ensure that learners understood what '*directly proportional* means.

Teacher B: *Let's look at those values hey. Eeeh, those, that's the table of results. But just looking at this you can tell us what happens to your current, just by looking at this. Can you all look at the values and try to state what is happening to the current as the voltage increases.*

Learner: *The higher the voltage, the higher the current*

Teacher B: *The higher the voltage the higher the…….*

Learner*: Current*

***Teacher B**: Current also increases, right and then there are some terms in physics that we use*

***Learner**: Directly proportional*

It shows that the teacher was aware that there is need to explain some of the terms in science, and the explanation was explicit with the help of the results obtained during the experiment which was carried out during the lesson, indicating the importance of language in practical work (Oyoo, 2012). However, some science words and everyday words used were not explained by Teacher B, such words include *resistance, variable*. These are words which are important in the understanding of science words and they needed to be explained in the context in which they were used. For example, the following excerpts illustrate the use of the word resistance during the lesson.

Teacher B: Which, let's say there is a bigger resistor and a smaller resistor, which of the two do you think will have a higher current?

Learner: The one with a bigger resistance

Teacher B: The one with a bigger resistor, resistance will have a higher current?

Learner: No sir, the opposite

Teacher B: You are saying opposite, so which is which now?

Learner: The higher the size the less the size.

The word *resistance* was never explicitly explained throughout the lesson. This means some learners might not have understood the meaning of the word in the context in which it was used.

However, teacher B made an attempt to explain some of the words which are used in everyday language but would assume a different meaning in science context (Oyoo, 2012). The word *control*, for example, can be used differently depending on the context. But Teacher B explained the word in the science context for better understanding by learners.

***Teacher B**: …… And the control is what?*

***Learners**: Temperature*

***Teacher B**: Control is temperature. By control we mean it doesn't change yeh? Control is temperature. It doesn't change.*

Differentiation between everyday meanings of words and their meanings in science

In instances when Teacher B explained some of the science words and everyday words in science context, like Teacher A he was not explicit in differentiating the meanings of words in science and their meanings in everyday use.

Quality and appropriateness of language used in asking questions and giving feedback to learners

The language level used in the grade 11 class was appropriate for that grade. The terms were relatively made simpler by Teacher B in the way he interacted with learners. He tried to make them more understandable as much as possible by asking a lot of questions. The only problem with questions asked, in most cases, required learners to give short answers.

Teacher B: is 2 Ohms. Then from there, what do we do? Remember we want to find the total hey? So what do we do there?

Learner: (says something inaudible)

Teacher B: R t, speak up

Learner: R1

Teacher B: R1

Learners: R4

Teacher B: Plus, R4

Learner: R_p

This did not help learners to develop their science language. Even in instances where the question required the learners to explain, they just gave short answers which might have an impact in answering questions in the examinations which require some explanation

4.3 Findings on teacher participant interviews

As stated in section 3.7.2.3, teacher interviews were conducted after observations of lessons by teacher participants. The purpose of the interviews was to get the teachers' perspective on the use of language by science teachers during teaching, and also to find out whether they are aware about the difficulties learners encounter with the science classroom language. The teacher participant interviews also sought to establish what teachers thought was the best approach to make the science classroom language accessible to learners. I listened to and watched the videotapes and also used field notes to select those issues that are relevant to the aims of the study. In the interview transcript (Appendix L), the teacher is only identified by letter A (Teacher A) to protect his identity and also to adhere to promise made that their real names will not be used in the research report. Only Teacher A was interviewed.

Teachers belief about the science classroom language

Teacher A believed that there is little difference between everyday language and the science classroom language. He believed that the general language (english in this case) is superior to the science language. Although the teacher said there is little difference between everyday language and science language, his explanation suggests that there is a big difference between the science language and everyday language. This is shown by his response when the researcher asked him whether there was any difference between everyday language and the science language.

***Researcher**: Do you think language in science is different from everyday language, for example english in general?*

***Teacher A**: No, there is little difference there, especially the specialised words. They differ a little bit. English language supersedes or controls the science language. the basic language, learners do have it, that is, in terms of meanings of words, the basic understanding or meanings of topics. When we talk of specialised language, like terminology is a problem because the English language does not explain much of these terms in terms of science especially physics. The English language does not explain deeply or vividly the specialised terms in science, especially physical science. For example, let me give an example, the 'focal point'. The English explanation of the 'focal point' can be different from the explanation in science. The word is quite different in English, and you need to explain it in science.*

This excerpt suggests that there is a big difference between everyday language and the science language because the teacher talk of specialised terminology, and this specialised terminology need to be explained. The teacher gave an example of *focal point* (a technical term), which he said its meaning is different from everyday English as compared to the meaning in science, hence there is a need to explain this term as it is used in science context. So the teacher appeared to be contradicting himself when he said there is little difference between the two languages, yet his explanation indicated a big difference. This shows a lack of explicit awareness of the difference between science language and everyday language (Oyoo, 2012).

The teacher went on to indicate that learners need not only be proficient in the language of instruction, but there must be proficient in the science language which concur with the observation by Oyoo (2015) and Rollnick (2000).

Teacher A: To be proficient in english does not mean that you will be skilful or well in specialised language. No it is not. It's only possible if you inter-marry those two together.

Teacher A: both of them must go together because you cannot do science without the background of the language of instruction. You cannot perform effectively if you do not have the required terminology in science to answer questions in examinations.

This emphasises the importance of proficiency in both the everyday language and also the language of science. This means that even those who are first language speakers of the language of instruction will not cope with science concepts if they are not proficient in the science classroom language. The language of science is difficulty irrespective of whether the learners are first or second language speakers of the language of instruction (Oyoo, 2007).

Teachers' awareness of the language as a barrier to learning science concepts

Teacher A appeared to be aware that the science language can be a barrier to learning science concepts, and teacher A even gave the percentage of learners in science who found the language difficult. Although the teacher did not explain how he arrived at the percentage, he was emphasising that the majority of learners struggle with the science language.

Researcher: Do you think learners have a problem with the language in science?

Teacher A: The science language starts with the science dictionary. Most learners find the language of science difficult. They need science dictionaries to explain science terms. 60% of our learners do not have basic science or physics background content. More than 60% do not have basic language

However, teacher A pointed out that in general teachers might not be aware that explanations of words in science may be different from their everyday meanings.

Researcher: Do you think teachers are aware that explanation of a word in ordinary English can be different in science?

Teacher A: Teachers actual may not be aware of that, because …., generally when you are teaching these kids, the mind set might not always go towards the specialised language, rather general terms. These teachers are not always aware of this except when we evaluate kids when we find that most of kids made mistakes one way or the other.

Teacher A also pointed out that teachers can contribute to difficulties learners encounter with the science language, especially if a teacher is not specialised in science. He pointed out that the teachers become only aware when learners are being evaluated.

What teachers think is the best approach to make the language accessible to learners based on Teacher A

On what teachers should do to lower the language barrier for science learners, Teacher A suggested that teachers should use explanations of meaning of words from textbooks. He emphasised that science dictionaries must be made available to learners so that they can learn definitions of words in the context of science. The suggestion that teachers should rely on textbook is perhaps supported by what was observed in some of teacher A's lesson. At times the teacher would just read the definition from the textbook, for example, the explanation of the term *frame of reference*. The teacher also suggested that the science language should be taught in the early years of schooling to build a solid foundation.

Researcher: *Since you acknowledge that language in science is a problem, how best do you think that this could be addressed on the part of the teacher? What do you think the teachers could do to improve the language?*

Teacher A*: The language of science must be taught from the first time the learner enters the classroom. The teacher should try his best to give meanings from the textbooks. Actual the textbooks we are looking at here are the dictionary meanings of the specialised words apart from the textbook.*

Teacher A*: Sometimes learners find it difficult to use the textbook. You can also refer them at the back of the textbook – the index where words are explained. This can be in addition to the science dictionary.*

The teacher in the above excerpt acknowledged that learners find the language used in science textbook difficult, but went on to suggest that teachers should refer learners to the index for definition of science words. The teacher here seemed to overlook the importance of explanation given by the teachers. He seemed to ignore the role of the teacher in mediating both the content and the language (Shaw, 2002). The teacher should therefore try and simplify the language of science as far as possible to help learners understand the science content, a point overlooked by Teacher A. Relying too much on textbook explanation definitions can lead to memorising, that is, learners reproducing what is textbooks without any understanding.

4.4 Discussion

This section discusses the findings of this study in relation to the research questions.

1 How do teachers make a distinction between everyday language and the science classroom language?

In this study, I observed lessons of two teachers in their normal teaching time, and also conducted an interview with one of the teachers, Teacher A. In relation to teachers making a distinction between everyday language and science classroom language, there was no explicit distinction in their teaching (Oyoo, 2012). There was also very little in terms of using learners' pre - understanding of everyday meanings of words to build a new understanding in the science context. Although one of the teachers, Teacher A, indicated that there was a difference between everyday language and science language, he did not point out this to learners in his lessons. Teacher A did not involve learners much during teaching. He did most of the talking. This is contrary to the constructivist approach to teaching and learning which states that learners bring to classroom ideas or pre-instructional knowledge that are sometimes so deep rooted that it becomes difficult to make learners accept new science concepts (Duit and Treagust, 2003). Teacher A acknowledged though that the science language is a specialised language, but in his teaching, he relied on the textbook, and even read definitions directly from the textbook. His teaching did not seem to complement his belief about the science language because there was little explicit distinction between science meanings of some words and their everyday meanings, if any. There are some everyday words used in science context which have been shown to be problematic in earlier studies, for example, *resistance* (Oyoo, 2012). Such words need to be explained explicitly to avoid any confusion that may arise with regard to their science meanings.

2 When do teachers explain both technical and non-technical words in their science teaching?

The source of difficulty of words in science is because they have different meanings in everyday context as compared to its use in science context. The teachers could have explained some of the words so that learners understood the words in the context in which it was used. Comparing the two teachers, however, the grade 11 teacher, Teacher B, explained a lot of the science terms and non-technical words, and used experiments to try and make learners understand the terms. This was evident in the explanation of the term *directly proportional*. The teacher drew the attention of learners to the increase in current through a resistor when the voltage across the resistor was increased. The grade 10 teacher, Teacher A, clearly pointed out in the interview that the explanation of the term *focal point'* in everyday language is different from science language, hence teachers needed to explain such terms. By explaining the words adequately, the learners are scaffolded well enough to enhance conceptual change (Scott, 1998). Teacher A, in a few cases used examples which learners were familiar with when he was explaining the difference between distance and displacement, but in most the time the teacher used the textbook, and I suppose the concepts were too abstract for learners. In such cases the science concepts were neither intelligible, plausible or fruitful (Posner et al, 1982).

3 What factors affect the teacher's effective use of science classroom language when teaching science?

One of the factors which appeared to contribute to the ineffective use of the science language is when teachers are not comfortable with the content. Teacher A, for example, at times seemed to struggle with the content and as result he could not effectively explain some of the terms, and he resorted to reading from the textbooks. By reading from the textbook without much explanation, the science concepts become too abstract and impersonal (Lemke, 1990). When the grade 10 teacher (Teacher A) was talking about negative acceleration, for example, the learners might have been left confused.

One of the contributing factors which came out of this study is lack of engagement of learners. The learners were not given the opportunity to verbalise their thoughts. The teachers missed the opportunity to know what the learner's pre-instructional knowledge about a concept was. It is likely this was because teachers assumed that because the words are common, then learners must automatically understand them when they are used in science context. Teachers were also under pressure to finish the syllabus. The grade 10 teacher observed (Teacher A), for example, was in hurry to go through the topic since learners were about write end of term tests. This rush to finish the syllabus sometimes result in teachers not explaining the words in science well enough for learners to comprehend.

4.5 Chapter Summary

This chapter presented and discussed the findings from lesson observations and teacher participant interview, starting with the lesson observation. The grade 10 lesson had less participation by learners compared to the grade 11 lesson. The explanation of some of the science words or everyday words used in science was not explicit. The findings also included teachers' beliefs about the science language. The chapter ended with the discussion of the findings in relation to the research questions and linking it to the literature. The lesson observation was analysed based on the analytical framework discussed in section 3.8. The teacher participant interview was interpreted in relation to the research questions. Relevant quotes were drawn from both the lesson observation and teacher interview transcript to illustrate the findings.

In the next chapter, I present the conclusion, implications, limitations and recommendations.

CHAPTER FIVE: CONCLUSION

5.1 Conclusion

The aim of the study was to investigate the quality of the teacher's science language when teaching physical science. The study sought to find out how teachers make a distinction between everyday language and science language when they explain both technical and non-technical terms in their science teaching. The study also sought to find out if there are any contributing factors which affect the effective use of science classroom language during science teaching. Therefore, the study aimed to answer the following research questions:

1. How do teachers make a distinction between everyday language and the science classroom language?
2. When do teachers explain both technical and non-technical words in their science teaching?
3. What factors affect the teacher's effective use of science classroom language when teaching science?

Data analysis approaches have been described in Section 3.8. It could be concluded from the data analysis that the teachers who participated in the study did not always explain both technical and non-technical terms as there were supposed to. The lesson observations revealed that some words that had different meanings in everyday language as compared to their science meaning were not explained. For example, the word *resistance* which I thought could have been explained in the context in which it was used was never explained. The other word which could have been explained in the context in which it was used was the word *fundamental.* It could be concluded that the teachers involved in the study overlooked the explanation of some terms in science. There were also instances when the explanation given of certain technical terms was not clear, which could have created some confusion in learners as described in section 4.2.1.1. This concur with findings in earlier studies that the way teachers use the science language can create confusion. This could be an indication of the teachers' unawareness of the difficulty learners do encounter with science language. One of the findings which came out of the study is that the content taught must be appropriate for grade level concerned. It is however important to note that some technical and non-technical words used in science context were well explained.

The teacher interview revealed that the teacher who participated in the interview, although he acknowledged that the words need to be explained in science context, he did not explain some words during his lessons. From the interview findings, it can be concluded that the teacher who participated in the study believes that there is little difference between the science language and everyday language as described I section 4.3. The teacher acknowledged that learners encounter difficulties with science language, and attributed this to lack of science background. Based on teacher interview findings it can also be concluded that the teacher who participated in the in the interview believed that teachers only contribute to the learners' difficulties with science language if they lack in science content. The teacher was making an assumption that if a teacher was good in science content, he would also be good in science language use. However, literature suggests that teachers need to explicit in their explanations so that learners do not become confused with the meanings of some words in science.

5.2 Implications and recommendations

In this study, it has been established that the two experienced and qualified teachers did not always explain both technical and non-technical words. Although the findings cannot be generalised over the whole of South African physical science teachers, it might be an indication of language problems in South African science classrooms. The difference between the everyday language and science language was not well understood by one of the teachers (Teacher A) as it is discussed in section 4.3. The lack of adequate explanation or non- explanation of some technical and non-technical words by the teachers in this study could be due to their unawareness of the difficulties learners encounter with the science language. Based on the findings in this study, it appears there is a need to create an awareness on the difficulties learners encounter with the science language, and also create an awareness on the role of the teacher's science classroom language. One the teacher participant indicated that there was little difference between everyday language and science language, yet literature has shown that there is a big difference and all categories of science of the science language are generally difficulty.

In South Africa, the teacher development programmes which I have participated in, mainly focused on the content. In order to address the issue of language in science, teacher development programmes should include the role of language in teaching and learning of science. This will create an awareness of the difficulty of science language. Workshops should also be organised specifically to discuss the issue of language in science, and the importance of teachers' quality of language in explaining both technical and non-technical terms. The teacher training programmes should include science language in their curriculum so that teachers are adequately trained in this field.

The study should also include teachers who are first language speakers of the language of instruction and teachers who are newly qualified. This will help to establish whether there is any difference in the use of the science language between first and second language teachers of the language of instruction.

5.3 Limitations of the study

5.3.1 Sample

The study involved only two teachers from the same school who are second language speakers of the language of instruction. The sample was not representative of the whole of South Africa, therefore, the findings from this study cannot be generalised over the whole of South Africa. Of the two teachers only one teacher participated in the interview, hence there were some gaps for Teacher B which could have been filled by conducting an interview. Although the sample was not representative of the whole of South Africa, the findings from this study together with findings from similar studies, could be used to understand the language problem in science classrooms.

5.3.2 Observation

Lesson observation is a complex process. The data can become so complex that it is difficult to know which data to use and which data to ignore (Opie, 2004). The transcribing part was difficult because some words were not audible because the teacher was moving around the classroom. Following the teachers around the classroom could have been a distraction to the flow of the lesson. The researcher was standing in one position, hence some words were not audible when the teachers were far away from the video recorder. Therefore, some valuable information could have been missed.

5.3.3 Interviews

One of the teachers did not honour the interview as agreed, as he kept postponing until he finally said he could not participate in the interview, which was off course within his right as per appendix H. This deprived the researcher of making a follow up on some issues which were observed during the lessons. This left the researcher with some unanswered questions about the second teacher. The researcher believes that had Teacher B participated in the interview, the findings could have been more comprehensive. This further affected the representativeness of the sample since only one teacher was interviewed.

5.4 Reflection on the research

This study has been an eye opener to me in terms of how we use the science language during teaching and learning of science. It has made me realise that sometimes as teachers we take explanation of some words in science for granted. I have realised the importance of explaining both technical words and non-technical words used in science context. The issue of language in science in South Africa is even more important, taking into account that South Africa is lagging behind in terms science education at both primary and secondary school level (World Economic Forum, 2015). This research has therefore made me understand the issue of science language better, and has equipped me with an invaluable experience. I believe that the challenges I encountered during data collection have better prepared me for future studies.

Many teachers are not comfortable having someone observing their lessons, let alone recording them. I am therefore thankful to those teachers who allowed me to observe their lessons. The data collection process itself is not an easy process. However, from this study, I believe that the challenges I encountered have prepared me to be a better researcher in future. Taking into account that South Africa is a multilingual country, future research in the area of language should be representative of different languages. In particular, participants should be drawn from both first language speakers and second language speakers of the language of instruction to find out if there are any differences in a South African context.

References

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

Ali, M., & Ismail, Z. (2006). Comprehension Level of Non-Technical Terms in Science: Are we ready for Science in English. *Jurnal Pendidik dan Pendidikan, Jil.* 21, 73-83

Anderson, C. (2010). Presenting and Evaluating Qualitative Research. American Journal of Education, 74 (8): 1-17

Bertram, C., & Christiansen, I. (2014). *Understanding research: An introduction to reading research* (1st ed.). Van Shailk. pp. 84-95

Brock-Utne, B. (2014). Language of Instruction in Africa – The most important and least appreciated issue. *International Journal of Educational Development in Africa.* 1 (1): 4-18.

Bradford, A. (2015). Live Science Contributor. http://www.livescience.com/20896-science-scientific-method.html

Christe, A. (2005). Constructivism and its Implications for Educators

Cohen, L., & Manion, L. (1989). Research Methods in Education. London: New York, NY: Routledge. 3rd Edition

Cohen, L., Manion, L, & Morrison, K. (2000). Research Methods in Education. London. Routledge/Falmer

Cook, S. W., & Goldin-Meadow, S. (2006). The Role of Gesture in Learning: Do Children Use their Hannds to change Their Minds? Journalm of Cognition and Development, 7(2); 211-232.

Cresswell, J. W. (2003). Research Design. Qualitative, Quantitative and Mixed Methods Approaches. (2nd ed.). Sage Publications

Department of Basic Education (2015). Senior Certificate Examination Technical Report 2015. Pretoria: Department of Education

Department of Basic Education (2011). Curriculum and Assessment Policy Statement Grades 10- 12: Physical Sciences

Department of Basic Education (2010). The of the Language of Learning and Teaching in South African Public Schools: A Quantitative Overview

Duit, R., & Treagust, F. (2003). Conceptual Change: a powerful framework for improving science teaching and learning.*International Journal of Science Education.* 25(6) 671-688.

Edwards, D., & Mercer, N. (1987). Common knowledge: The development of understanding in the classroom: Routledge

Fellows, N. J. (1994). A window into thinking: Using student's writing to understand conceptual change in science learning. *Journal of Research in Science Teaching*, 31: 985 – 1001

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

Feynman, R. P. (1998). The Uncertainty of Science. *Meaning Of It All*. Penguin Books: London: England

Field, A. (2005). Discovering Strategies using SPSS. (2nd ed.), London. Sage

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

Guba, E. G., & Lincoln, Y. S. (2005). Paradigmatic controversies, contradictions, and emerging confluences. In N. K. Denzin & Y.S. Lincoln (eds). The Sage Publications.

Hammond, J. (2001). Scaffolding and Learning in Language and Literacy Education. Perth

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

Henderson, J. & Wellington, J. (1998). Lowering the language barrier in learning and teaching science. *School Science Review*, 79(288), 35-46.

Hewson, P. W. (1992). Conceptual change in science teaching and teacher education. Paper presented at a meeting by the National Center for Educational Research, Document and Assessment, Ministry of Education and Science, Madrid, Spain. *Journal of Research in Science Teaching*

Howe, A. C. (1996). Development of Science Concepts within a Vygotskian Framework. *Science Education,* 80(1): 35-51

Howie, J. S. (2003). Language and other background factors affecting secondary pupils' performance in mathematics in South Africa. African Journal of Research in Mathematics Science and Technology Education, 7:1 – 20

Jansen, J & Taylor, N. (2003). Educational Change in South Africa 1994 – 2003: Case Studies in Large – Scale Education Reform. *Country Studies in Education Reform and Management Publication Series,* Vol. 2 No: 1

Jarret, D. (1999). The inclusive classroom: Teaching mathematics and science to English Language learners. Oregon: North West Regional Educational Laboratory.

Jegede, O. J, & Aikenhead, G. S. (1999). Transcending Cultural Borders: Implications for Science Teaching. *Journal for Science and Technology Education.* 17 (1): 45 – 66

Jones, M. G., & Brader – Araje, L. (2002). The Impact of Constructivism on Education: Language Discourse and Meaning. American Communication Journal, vol.5 :3

Johnson, B., & Christensen, L. (2008). Educational Research: Quantitative, Qualitative and Mixed approaches. London: SAGE Publications

Joppe, M. (2000). The Research Process. The Quantitative Report Journal, 8 (4): 597 -607.

Key, J. P. (2002). Research Design in Occupational Education: Questionnaire and Interview as Data Gathering Tools. Oklahoma State University

Lantolf, J. P. (2003). Interpersonal Communication and Internalisation in the Second Language Classroom. In A. Kozulin (Ed.) *Vygotsky's Educational Theory in Cultural Context* (pp.349-370). London: University Cambridge Press

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

Lemke, J. L. (1990). Talking Science, Learning and Values. Norwood NJ. Abex.

Lorsbach, A., & Tobin, K. (1992). Constructivism as a referent for science teaching. *NARST Newsletter*, 30: 5-7.

Mammino, L. (2010). Language aspects in science and technology education: novel approaches for new technologies. In *Proceedings of the 7th WSEAS international conference on Engineering education* (pp. 480-486). World Scientific and Engineering Academy and Society (WSEAS).

McMillan, J. H. (1996). Educational Research: Fundamentals for the Consumer. (2nd ed.). HarperCollins, College Publishers

Mji, A., & Makgatho, M. (2006). Factors associated with high school learners' performance: a spotlight on mathematics and physical science. *South African Journal of Education*, 26(2): 253-266

Moje, E.B. (1995). Talking About Science: Interpretation of the Effects of Teacher Talk in a High School Science Classroom. Journal of Research in Science Teaching, 32 (4): 349-371

Msimanga, A., & Lelliot, A. (2014). Talking science in multilingual contexts in South Africa: Possibilities and challenges for engagement in learners' home language in high school classrooms. International Journal of Science Education, 36 (7), 1159 – 1183.

Muralidhar, S. (1991). The Role Language in Science Education: Some Reflections from Fiji. *Research in Science Education;* 21: 253-262

Nanda, S., & Warms, R. L. (eds), (2011). 'Communication' (Chapter 5) of Cultural Anthropology (10th Edition), Belmont, California, Wadsworth, p. 76 -96.

O'Connell, B. (2009). The Dinaledi Project Report: Report from strategic engagement between National Department of Education and Business on increasing support for Mathematics and Science Education in schools. University of Cape Town

Ono, Y., & Ferreira, J. (2010). A case study of continuing teacher professional development through lesson study in South Africa. *South African Journal of Education*, 30 : 59-74

Opie, C. (2004). Doing educational research. London: Sage Publications, Chapter 1, 2. What is educational research? p. 1 -33.

Oyoo, S.O. (2000). Understanding of some Non – Technical Words in Science and suggestions for the effective use of Language in Science Classrooms. M.Ed (Science Education) dissertation. School of Education. University of Leeds. Leeds. United Kingdom

Oyoo, S. O. (2004). Effective teaching of science: the impact of physics teachers' classroom language. Phd thesis. Faculty of Education: Monash University, Clayton Campus, Melbourne, Victoria, Australia

Oyoo, S. O. (2007). Rethinking Proficiency in the Language of Instruction (English) as a Factor in the Difficulty of School Science. *International journal of Learning,* 14(4): 231-241

Oyoo, S.O. (2008). Going round the foreign language problem in African science classrooms. *Teaching and Education for Teaching in Developing Countries* (pp. 103-119). SACOST, University of Education, Winneba

Oyoo . S. O. (2011) . Foreign Languages in African Science Classrooms: Perspective on And Approaches to Language use during Teaching: Distance Education and Teachers' Training in Africa: Ensuring the Highest Possible Quality of Education in a changing Africa. DETA, Maputo

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, 849-872*

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. (2014). Handout for the course SCED 7011: Language and communication in science education. An Introduction and Overview.

Oyoo, S. O. (2015). Helping learners become fluent in the language of science classrooms. The Conversion. Available at http://www.theconversion.com/helping-learners-become-fluentinthelanguageofscienceclassroom. 41540

Oyoo, S. and Nasimu, S. (2015). The place of proficiency in the language of instruction: the challenges Grade 12 physical science learners encounter with meanings of everyday words used in science context. In L. Makalela (ed), *New Directions in Language and Literacy Education for Multilingual Classrooms* (Chapter 2, pp. 39 - 66). Cape Town: CASAS.

Piaget, J. (1964; 2003). Development and learning. *Journal of Research in Science Teaching*, 40, supplement, S8 – S18

Piaget, J. (1958). The growth of logical thinking from childhood to adolescence. *AMC*, 10 -12

Pickersgill, S., & Lock, R. (1991). Student understanding of selected no-technical words in science. *Research in Science and Technological Education,* 9 (1): 71 - 79

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of scientific concept: Toward a theory of conceptual change. *Science Education*, 66: 211-227

Probyn, M. J. (2005). Learning Science through Two Languages in South Africa. *Proceedings of the 4th International Symposium on Bilingualism,* Somerville, MA: Cascadilla Press.

Prophet, B., &Towse, P. (1999). Pupils' understanding of some non technical words used in science. *School Science Review,* 81(295) : 79 -86

Punch, K. F. (2009). Introduction to Research Methods in Education. London: SAGE Publications.

Puntambekar, S. (2005). Tools for Scaffolding Students in Complex Learning Ennvironment. What have we gained and what have missed? *Educational Psychologists*, 40(1) :1-12

Richardson, V. (1997). Constructivist Teaching and Teacher Education: Theory and Practice. Constructivist Teacher Education: Building a World of New Understanding. Falmer Press. London.

Rollnick, M. (2000). Current Issues and Perspectives on Second Language Learning of Science. *Studies in Science Education,* 35: 1, 93 – 121

Schoerning, E. (2014). The effect of Plain-English Vocabulary on Student Achievement and Classroom Culture in College. *International Journal of Science and Mathematics Education,* 12: 307-327

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. H., Asoko, H. M., Driver, R. H., & Emberton, J. (1994). Working from children's ideas: An analysis of constructivist teaching in the context of a chemistry topic. In P. Fensham, R. Gunstone, & R. White (Eds.), The content of science. London: Falmer.

Scott, P. H., Asoko, H. M., & Driver, R. H. (1991). Teaching for Conceptual Change: A Review of Strategies

Shaw, J. (2002). Linguistically responsive science teaching. *Electronic Magazine of multicultural Education*, 4 (1): 26

Taylor, J. A. (2001). Using practical context to encourage conceptual change. An instructional sequence in bicycle science. *School Science and Mathematics*, 10 (3): 117 -125

Taylor, N., & Prinsloo, C. (2005). The Quality Learning Project Lessons for High School Improvement in South Africa

Thorne, K., Gericke, N. M., & Hagberg, M. (2013). Linguistic Challenges in Mendelian Genetics: Teachers' Talk in Action. *Science Education,* 97 (5): 695-722.

The Citizen Newspaper, Thursday 30 December 2015

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press. Chapter 6 (pp. 79-91)

Wellington J. & Osborne, J. (2001). *Language and Literacy in Science in Education.*Buckingham, Philadephia: Open University Press

Wilson, J. M. (1999). Using words about thinking: content analyses of chemistry teachers' classroom talk. *International Journal of Science Education,* vol. 21(10): 1067-1084

World Economic Forum (2015). The Global Information Technology Report 2015: ICTs for Inclusive Growth

World Economic Forum (2014). The Global Information Technology Report

Ziman, J. M. (1987). 'Academic' science. An introduction to Science Studies: The Philosophical and Social Aspects of Science and Technology. New York: Cambridge University Press

APPENDIX A

Wits School of Education

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19 November 2015

Student Number: 692665

Protocol Number: 2015ECE056M

Dear Emmanuel Ncube

Application for ethics clearance: Master of Science

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:

Investigating Physical Science teachers' classroom use of language during teaching

The committee recently met and I am pleased to inform you that **clearance was granted**.

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,

Wits School of Education

011 717-3416

cc Supervisor: Prof Sam Oyoo

APPENDIX B

GAUTENG PROVINCE

Department: Education
REPUBLIC OF SOUTH
AFRICA

For administrative use:
Reference no: D2016 1 210
enquiries: Diane Buntting
011 843 6503

GDE RESEARCH APPROVAL LETTER

Date:	11 August 2015
Validity of Research Approval:	11 August 2015 to 2 October 2015
Name of Researcher:	Ncube E.Z.
Address of Researcher:	P.O. Box 1660; Highlands North; 2037
Telephone I Fax Number's:	076 164 2914
Email address:	ezncube@yahoo.co.uk
Research Topic:	Investigating Physical Science teachers' classroom use of language during teaching.
Number and type of schools:	ONE Secondary School
Districtis1HO	Johannesburg East

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved. A separate copy of this letter must be presented to the Principal, SGB and the relevant District Head Office Senior Manager confirming that permission has been granted for the research to be conducted. However, participation is VOLUNTARY.

The following conditions apply to GDE research. The researcher has agreed to and may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:

CONDITIONS FOR CONDUCTING RESEARCH IN GDE

1 . The District Head Office Senior Manager/s concerned must be presented with a copy of this letter;

2. A copy of this letter must be forwarded to the school principal and the chairperson of the School

Governing Body (SGB);

JCCLCLCO / 2015/ 08/12

1

Making education a societal priority

Governing Body (SGB);

Office of the Director: Knowledge Management and Research

9th Floor, 1 1 1 Commissioner Street, Johannesburg, 2001

P.o. Box 77101 Johannesburg. 2000 Tei: (011) 355 0506

Email: David.Makhado@gauteng.govza

Website: www.education.gpg.gov.za

3. A letter / document that outlines the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District Head Office Senior Managers of the schools and districts/offices concerned;

4. The Researcher will make every effort obtain the goodwill and co-operation of al] the GDE officials, principals, SGBs, teachers and learners involved. Participation is voluntary and additional remuneration will not be paid;

5. Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal and/or Director must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage;

6, Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year. If incomplete, an amended Research Approval letter may be requested to conduct research in the following year;

7. Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education, 8. It is the researcher's responsibility to obtain written parental and learner consent;

9.The researcher is responsible for supplying and utilising his/her own research resource¾ such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources:

10. The names of the GDE officials, schools, principals, parents. teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations;

I l , On successful completion of the study the researcher must supply the Director: Education Research and Knowledge Management with an electronic copy (and a Hard copy if possible) as well as a Research Summary of the completed Research Report;

12. The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned; and

13. Should the researcher have been involved with research at a school and/or a district office level, the Director and school concerned must also be supplied with the Research Summary of the study.

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards

....

Dr David Makhado

Director: Education Research and Knowledge Management

DATE: 2015/08/12 ....

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Making education a societal priority[redacted]

Office of the Director: Knowledge Management and Research

9th Floor, i l l Commissioner Stieet, Johannesburg, 2001

P.O. Box 7710. Johannesburg, 2000 Tel: (01 i) 355 0506

Email: David.Makhado@gauteng.govza

Website: www.education.gp¶gov.za

APPENDIX C

LETTER TO THE PRINCIPAL

Wits School of Education

University of the Witwatersrand

DATE:

Dear Principal

My name is Emmanuel Z. Ncube. I am an MSc student in the School of Education at the University of the Witwatersrand.

I am doing research on "***Investigating physical science teachers' classroom use of language during teaching".***

My research involves investigating the physical science teachers' use of language during teaching to help learners learn science concepts. Language of science is reportedly a challenge to learners. How it is used in class is going to impact on understanding of science concepts. Data will be collected by means of observation of two lessons per teacher. Follow up interviews will be done for each teacher whose lessons were observed. Two teachers will be requested to participate in this study. Lesson observation will take place during normal teaching time. Lesson observations will take a maximum of 40 minutes per lesson. Follow up interviews will be conducted in teacher's office, and each interview will last for 15 minutes. Lesson observations will be videotaped and teacher interviews will be audiotaped. The data will be used for academic purposes, and possibly for presentation at a conference and/or published as a general paper in journal paper.

The reason why I have chosen your school is because I am a teacher in the school. Since data collection involves observation of lessons it will be easy to arrange with teachers who are going to agree to participate in the study with minimum disruption of lessons.

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. Research data will be kept under lock and key at Wits School of Education, and will only be accessible to the researcher and the supervisor. 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,

Emmanuel Z. Ncube

12 Carmel, Fortsque & Hopkins Streets, Yeoville

eznncube@yahoo.co.uk

Cell: 076164 2914

APPENDIX D

INFORMATION SHEET LEARNERS

DATE:

Dear Learner

My name is Emmanuel Z. Ncube and I am an MSc student in the School of Education at the University of the Witwatersrand. I am doing research on "***Investigating physical science teachers' classroom use of language during teaching".***

My investigation involves language use in the science classroom. I am doing this project for a Masters in Science Education. The data will be used for academic purposes, and possibly for presentation at a conference and/or published as a general paper in journal paper.

I was wondering whether you would mind if I sit in two of your lessons and observe the lesson. I will not actively participate in the lesson. Lesson observation will take place during your normal Physical Science periods, and the lessons will be videotaped. However, the focus of the study will be on the teacher.

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. 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. You will not be paid for participating in the study.

I will not be using your own name but I will make one up so no one can identify you. All information about you will be kept confidential in all my writing about the study. Also, all collected information will be stored safely at the Wits School of Education 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

Emmanuel Z. Ncube

12 Carmel, Fortsque & Hopkins Streets, Yeoville

ezncube@yahoo.co.uk

Cell: 076164 2914

APPENDIX E

Learner Consent Form

Please fill in the reply slip below if you agree to participate in my study called:

Investigating physical science teachers' classroom use of language during teaching

My name is: ________________________

Circle one

Permission to observe you in class

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.
- All the data collected during this study will be destroyed within 3-5 years after completion of my project.

Sign_____________________________ Date___________________________

APPENDIX F

INFORMATION SHEET PARENTS

DATE:

Dear Parent

My name is Emmanuel Z. Ncube and I am a student in the School of Education at the University of the Witwatersrand.

I am doing research on "***Investigating physical science teachers' classroom use of language during teaching".***

My research involves the investigation of the quality of the physical science teachers' classroom use of language. Data will be collected by means of observation of two lessons per teacher. Two teachers will take part in the study. Lesson observation will be conducted during normal Physical Science lessons and these lessons will be videotaped. However, the focus of the study is on the teacher. Follow up interviews will be done for each teacher whose lessons were observed.

The reason why I have chosen your child's class is because your child is doing physical science and is taught by the physical science teacher who has agreed to participate in this study.

I was wondering whether you would mind if you allow your child to participate in this study during my lesson observations.

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 the study. The research data will be kept under lock and key at the Wits School of Education.

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,

Emmanuel Z. Ncube

12 Carmel, Fortsque & Hopkins Streets, Yeoville

ezncube@yahoo.co.uk

Cell: 076164 2914

APPENDIX G

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:

Investigating physical science teachers' classroom use of language during teaching

I, ________________________ the parent of ______________________

Circle one

Permission to observe my child in class

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.
- All the data collected during this study will be destroyed within 3-5 years after completion of my project.

Sign______________________________ Date____________________________

APPENDIX H

INFORMATION SHEET TEACHERS

DATE:

Dear

My name is Emmanuel Z. Ncube and I am an MSc student in the School of Education at the University of the Witwatersrand.

I am doing research on ***"Investigating physical science teachers' classroom use of language during teaching".***

My research involves investigating the physical science teachers' classroom use of language during teaching. Your participation will involve me sitting in your lessons (2) and observing. It will also involve participating in a 15-minute interview after lesson observation. Follow up interviews will be conducted after school in your office. Please be informed that you will be videotaped during the lesson and audio taped during the interview. The results and findings will be submitted as a research report to Wits School of Education.

The reason why I have chosen your school is because I am a teacher in the school. Since data collection involves observation of lessons it is convenient since I can easily arrange with you without disrupting lessons.

I was wondering whether you would mind if you would allow me to observe your lessons and interview you thereafter.

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. The research data will be kept under lock and key at the Wits School of Education

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,

Emmanuel Z. Ncube

12 Carmel, Fortsque & Hopkins Streets, Yeoville

ezncube@yahoo.co.uk

Cell: 076164 2914

APPENDIX I

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:

Investigating physical science teachers' classroom use of language during teaching

I, _________________________ give my consent for the following:

	Circle one
Permission to observe you in class	
I agree to be observed in class.	YES/NO
Permission to be audiotaped	
I agree to be audiotaped during the interview	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 or videotaped
- all the data collected during this study will be destroyed within 3-5 years after completion of my project.

Sign______________________________ Date____________________________

APPENDIX J

The Teacher Interview schedule

This schedule is for the interview of the teachers after observing their lessons.

Example questions to be posed to the teacher:

1. Do learners experience difficulties with the science language?
2. What could be the cause of the difficulty?
3. Is the science language different from the everyday language? If yes, how is it different?

APPENDIX K

TEACHER A LESSON OBSERVATION TRANSCRIPT

Lesson 1

NB: words in italics are direct words from the teacher

What is speed? ….. Speed is a scalar quantity (teacher does not allow time for learners to respond).

What is a scalar quantity? Speed is a scalar what? Speed is a scalar quantity.

What did we say is a scalar quantity?

Learners: quantity with a magnitude only (response inaudible*)*

Yes it has a magnitude. If we say magnitude, it means it has a size.

So speed is a scalar quantity because it has size. That is what a scalar quantity is. Velocity ………. Is it a scalar quantity? What is velocity?

Learners: vector quantity (learners responds)

Velocity is a vector quantity. Both speed and velocity are quantities. One is vector quantity while the other is scalar quantity.

Speed = $\frac{Distance}{Time}$ **(Teacher writes the formula on the board). The teacher comments that it is important.**

Speed is measured in metres per second or kilometres per hour. The SI unit –, remember I said SI unit stands for Standard Internationale Unit. The SI unit for speed is what? It is metres per second. Remember I said speed is a scalar quantity because it has magnitude only. Velocity is a vector quantity because it has magnitude and direction. If you look at your vehicle or taxi, if look at the speedometer and is moving very fast. It is distance over time.

Let us quickly look at displacement. Sorry let us look at velocity. What is a velocity?

The teacher writes the following on the board:

Velocity = $\frac{Displacement}{Time}$ **or** $\frac{Change\ in\ displacement}{Time}$

Let us quickly look at displacement

What is displacement? (Teacher asks the question three times*)*

Learner: Change in position

Change in position, No (teacher responds to the learner).

Learner: Change in position

I said no!

What is change in displacement? What is displacement?

Displacement is distance in a given or specified direction. Didn't I tell you that? I did. You forget fast. When I say I travel 20km east, the direction is eastwards and that is displacement. And when I say I travelled 20km, this is distance. Mr …….. is driving very fast. What is the speed? 2okm per hour. We are talking about what, speed. But if Mr ……… is driving at 20km per to Joburg, we are now talking about velocity.

Velocity is measured in metres per second just like speed, but must specify the direction. When we mention direction, we are talking about what? Velocity not speed.

Let us go straight to average speed. When we say average speed, when put speed average, Average speed, what do we mean by average speed? Change in distance over time taken

Teacher writes the following formula on the board?

Average speed = $(x_f - x_i)/(t_f - ti)$

Let us quickly look at average velocity before we solve some questions. What is average velocity? Average velocity is change in displacement over change in time.

Velocity = $\frac{\textit{Change in displacement}}{\textit{Time}}$ **(formula written on the board)**

People I want you to underline in your textbook the word average speed.

NB: the average speed is written as follows in the textbook:

Average speed = $\frac{\textit{Total distance travelled}}{\textit{Total time}}$

<u>Lesson 2</u>

Vector and scalar quantity

Vectors have size (magnitude) and direction. Scalars are what? Are quantities with size only. What is the other word for size? Teacher continues without allowing learners to respond to the question but writes on the board to illustrate the difference.

Let us look at examples of scalar quantities. What do you understand by scalar quantities? What are examples of vector quantities from you own perspectives? ... What is a vector quantity?

Learner responds: Any quantity that has size and direction

Yes, any quantity that has size and direction. People let us quickly look at examples. The first one is displacement. The next one which we are going to look at is called velocity. The other one is weight, and the next one is what? It is force.

Let us now look at examples of scalars. One example is time. Time is an example of scalar. What else is an example of scalar?

Learner : mass

Yes mass. Mass is a scalar quantity. What else is an example of a scalar quantity? Mass measures the size.

Charge (Learners respond as a class)

Yes charge…… yes thank you charge is an example of a scalar. The other one is distance.

There is what we call fundamental units. Unit of measurement. This is important because every quantity must be measured. Remember what I said? I said quantities are measurable. They what, they measurable.

What is displacement? Displacement is distance in a specified direction or distance travelled in a given direction.

Teacher writes the formula on the board as follows:

Displacement = $\frac{dist.travelled\ in\ a\ given\ direction}{time}$

NB: teacher realises that he has the wrong formula for distance and quickly erases the word time.

*The unit of measurement is metres. There is no time attached to it, it's metres (*Teacher erases the word time from the formula he wrote for displacement). *Let's say for example metres east. For example when I say 30km east, that is displacement. But when I say 30km, that is distance. Let's us quickly look at velocity. Velocity is now change in displacement over time ……. Over what, over time.*

Teacher writes the formula for velocity as follows:

Velocity = $\frac{Change\ in\ displacement}{time}$

If we say 30km/s east, we are talking about displacement, velocity neh. We are talking about what? Velocity. When we say 30km/s east we are talking about velocity. This an example of velocity.

What about example of speed. Speed is distance over time. Distance over what? Overtime. Speed is the distance over time taken.

Teacher writes the following formula on the board:

Speed = $\frac{Distance}{time}$

This is an example of scalar quantity neh. If you are driving a car for example, voom voom…., and people say you driving fast, that is speed. Speed is distance over time measured in kilometres/hour or metres per second. It is a scalar quantity. If a Mr ….. is not driving fast, you tell the driver: please drive fast I want to go and buy …………….. (in audible) in Jozi. So speed is an example of scalar quantity. Remember this can also be measured in kilometres per hour or metres per second. Units are very important. We are talking about standard unit.

Ok let us quickly look at force. What is force? People watch this. ***Watch this chalk (*Teacher throws the chalk upwards and catches on its way down**). *I pick it up. It is a force. Force is a scalar quantity or vector quantity?*

Learner: scalar quantity'

Yes force is a scalar quantity neh. It's a scalar quantity. Why do you say is a scalar quantity?

Learner response in audible

No it is not a scalar quantity. Remember I threw a chalk (teacher demonstrates). There was direction. Force has a direction. A scalar quantity does not have direction. You …………….

*Force is an example of a vector quantity. Force is what? Force is mass times acceleration. As I throw the chalk, it goes with a speed. When you multiply mass and acceleration, sometimes the acceleration is linear (*Teacher demonstrates a horizontal movement) *or is acceleration due to gravity which is gravitational force. As I throw it moves with acceleration or acceleration due to gravity which is force. Mass is measured in Newtons. Force is kilograms times acceleration. Force is a vector quantity, it is a measurement of the mass of the body and its acceleration. Every force must have a direction and size. Acceleration is change in velocity over time. The SI unit is the newton (N). the last one we have is weight. What is weight? Wena (you) you are seated neh. Are you not seated? You are seated on a chair, neh. You are exerting your force or weight. If this is a chair and wena (you) are seated on the chair (draws a diagram to illustrate), you are exerting a force on the chair and that force is your weight.*

Let's assume you are 30kg, that 30kg is not your weight. It is your mass. We need to consider the acceleration due gravity. The change in velocity over time towards the centre of the earth. That acceleration due to gravity is $9.8m/s^2$.

The teacher writes the formula for force and weight:

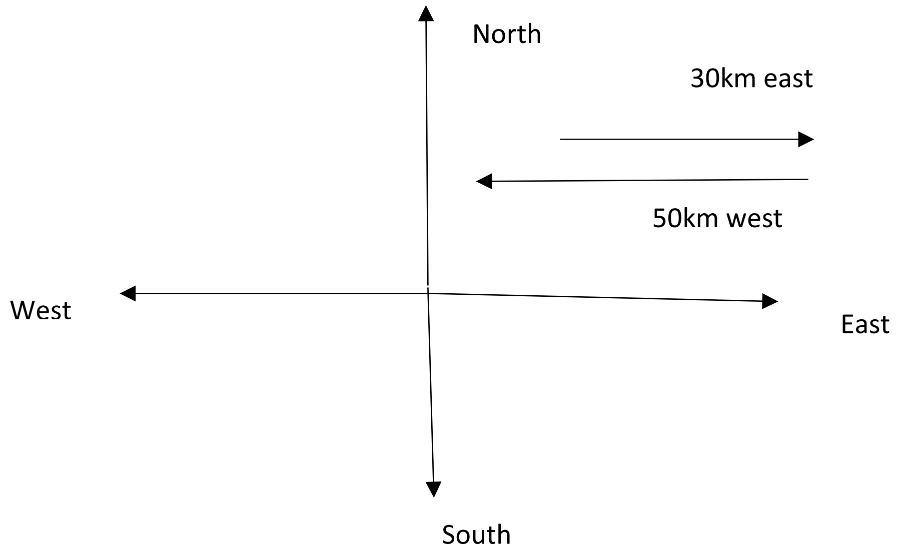
W = mg

F = ma

Both force and weight and force are the same. This one (F=ma) the acceleration is linear and weight the acceleration is downwards. Let us look at examples of force. Let us look at how we represent vectors. We represent vectors using arrows and using what we call lines.

For example, let us look at that. Force is a vector neh. Let us look at vector F_1; 30km east. Let us look at another vector F_2, 50km west.

Teacher draws a diagram to illustrate vectors as shown below:

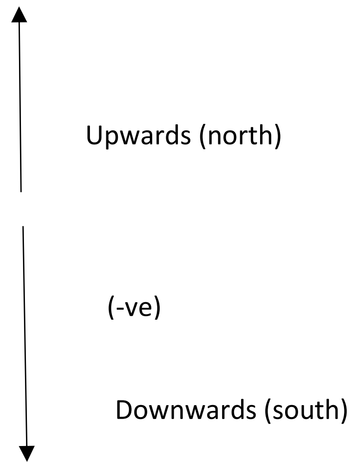


We use the arrows and the lines to represent vectors. The lines represent the what? The magnitude and the arrow represent the what? The direction. And we also try to add to find the solution of vectors.

Let us look at example of what? Let us look at summation of vectors, total of vectors.

Total vector is equal to f_1 plus f_2 (Total vector = $F_1 + F_2$). If a vector is acting upwards, it is positive and if a vector is acting downwards, it is negative.

Teacher draws a diagram to illustrate "total vector".



If a vector is acting upwards, it is upward force or north. This vector is a positive vector. If it is acting downwards, this vector is acting downwards also known as south. This vector that is going south is also called a negative vector. Another way of representing vectors is east and west. The vector that goes to right or the east is called a positive vector. Another vector going opposite to west is called a negative vector.

Lesson 3

Are these vectors are they equal? What do mean by equal vectors?
Learner: …………………… (not audible)

When we talk of equal, we talking about size, we talking about what? Size. They are same, they are equal forces. But their directions are different. They must be equal forces. You know what is called equal? If F_1 equal to 2N downwards and F_2 is equal to 2N upwards, these force are equal but their directions are different. There are the same forces and same size, equal forces. Equal forces equal vectors, but different directions. These forces are equal but the directions differ. The equal vectors in the sense that their magnitude is the same but their direction is different.

What is a resultant force? The upward force is positive and the downward force is negative.

Teacher does some calculations on the board as follows:

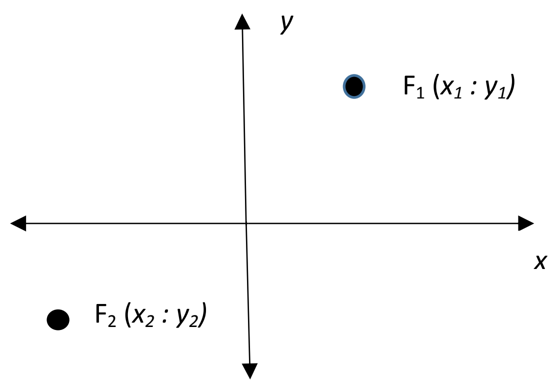
F_R = 2 + (-2)

= 2-2

= 0

Let's look at position. Position is where a particular force is or where a particular vector is located. We normal use what we call cartesian plane.

Teacher draws the cartesian plane on the board.



To locate the position F_1 use the x and the y coordinates. We need to find the x and y coordinates of that force. We need to do what? We need to find the x and y coordinates. For example the position of point F_1 is x against y (x_1;y_1). You can have another force, F_2 acting somewhere, it can determined by the coordinates (x_2 : y_2). You can be asked to determine the position or the distance between two vectors on a cartesian plane. This is the same calculation in maths. You have done this calculation in maths. If are given these two forces on are acting at a position, you can determine their position and also the distance between the distance between the two forces. The distance between the two points is a straight line joining the forces. You know how to determine the distance of the line from maths. How do you determine the distance of the line? How do you determine the distance of the line? What is the distance

Learners not responding and teachers write the distance formula and uses it to calculate the distance between the points after giving coordinates to the two points on the graph for example F_1 (2; 4) and F_2 (-3 ; -3).

*Let us quickly look at what they have in the textbook. There is what we call a frame of reference. A frame of what? A frame of reference. A frame of reference is a set of reference points which has set of axes that enables position of an object to be defined (***Reading the definition from the textbook***). For example F1 has a frame of reference (x_1 :y_1) and F_2 has a frame of reference (x_2 : y_2). Any object or any quantity that is motion must have a position, must have have a frame of reference. That frame of reference is determined by the x and y coordinates.*

Distance and displacement

What is the difference between displacement and distance? What is the difference? Distance is a scalar quantity and displacement is a vector quantity. Displacement is a vector quantity because it has direction. For example, when we say somebody is 5m away, that is distance. But when we say somebody is a distance of 5m east, thaft is now displacement. Distance can be said to be D = 5m, whilst displacement can be written as Dx = 5m (east). Displacement can also be regarded as distance to the left or right. Displacement, Dx, can be written as Dx = X_{final} –$X_{initial}$. This means $X_2 – X_1$ or change in x.

I will also briefly talk about acceleration. What is acceleration? Acceleration is the rate of change of velocity. Acceleration is measured in metres per second squared. Acceleration can either be positive or negative. Negative acceleration is called retardation, deceleration or declaration. Yes retardation, deceleration or declaration.

APPENDIX L

Teacher A Interview Transcript

Researcher: Do you think learners have a problem with language in science?

Teacher: The science language starts with the science dictionary. Most of our learners find the language in science difficult. They need science dictionaries to explain science terms. 60% of our learners do not have basic science or physics background content. More than 60% do not have basic language of science.

Researcher: Do you think language in science is different from everyday language, for example English in general?

Teacher: No, actual there is little difference there, especially the specialised words. They differ a little bit. English language supersedes or controls the science language. The basic language, learners do have it, that is, in terms of meanings of words, the basic understanding or meanings of topics. When we talk of specialised language, like terminology is a problem because the English language does not explain much of those terms in terms of science, especially physics. The English language does not explain deeply or vividly the specialised terms in science, especially physical science. For, example, let me give an example, the focal point. The English explanation of the focal point can be different from the explanation in science. The word is quite different from English, and you need to explain it in science.

Researcher: Do you think teachers are aware that the explanation in ordinary English can be different in science?

Teacher: Teachers actual may not be aware of that, because ………., generally when you are teaching these kids, the mind-set might not always go towards the specialised language, rather the general terms. Teachers are not always aware of this except when we evaluate kids when we find that most of kids have made mistakes one way or the other.

Researcher: Do you think teachers overlook some of the words in science, for example, spontaneous reaction, negligible ……

Resistance (teacher interrupts)

Teacher: Teachers do explain these terms. For example, the word circuit, you need to explain the terms involved or ways in which it is used in electricity to the kids, before you go into detail. There is what we call induction during teaching process. You try to learn what the learner has in mind concerning what you are about to teach. Actual that is entry behaviour. You use that entry behaviour to stimulate your teaching process by explaining those terms. After explanation of those terms, you go into detail of the topic before you start discussing the general topic with kids. So we start from terms, explanation of the terms and you go into detail of the topic which you are about to offer the kids otherwise you may find that at the end of the day you may not realise your objectives of lesson precisely.

Researcher: Do you think teachers contribute to the understanding or misunderstanding of science terms.

Teacher: Yah, yes. Teachers can contribute to misunderstanding of terms or words. It depends on the background of the teacher. Teachers can contribute to the success or failure of the children. If somebody is not specialised in the field of study, he or she may not be carrying the required standard of that subject. This is why teachers of different fields are being updated to their areas of specialisation. Teachers can easily contribute to the success or failure of the kids.

Researcher: Since you acknowledge that language in science is a problem, how best do you think that can be address on the part of the teacher? What do think the teachers could do to improve the language?

Teacher: The language of science?

Researcher: Yes

Teacher: It depends. Language of science begins on the first phase of learner school work, eh … eh, for example written as the basic foundation. The language of science must be taught from the first time the learner goes to school or the learner enters the classroom. The teacher should try his best to give meanings from textbooks. Actual the textbooks we are looking at here are the dictionary meanings of the specialised words apart from the normal classroom textbooks. If we can get these science dictionaries and give those to the learners that will help learners understand these specialised terms. Even if you are explaining, you refer them to a specific page. Fortunately in our school we are lucky we have these dictionaries. It is unfortunate that the science dictionaries are given to higher grades, for example, grades 11 and 12 whereas those in grade 10 do have the chance to use those dictionaries.

Researcher: Suppose a learner is good in English, do you think that the learner will be automatically be good in science or science language? Does proficient in English translate to proficient in ………..

Teacher: to be proficient in English does not mean that you will be skilful or well in specialised science language. No its not. It’s only going to be possible if you inter marry those two together. For example, if a learner speaks or knows English well, it does not mean he is going to do well in science if he does not have the required basic terminology to write the science. So the only way is to make sure that in as much as the learner may understand simple English, and use it to answer questions, you can point out to the learners the importance of using this science language in order to interpret the questions or in order to write accurately otherwise if they use general language to answer questions they may not get maximum marks.

Researcher: In other words, you are saying there is proficient in the language of instruction and proficient in the science language?

Teacher: Both of them must go together because you cannot do science without the background of the language of instruction. You cannot perform effectively if you do not have the required terminology in science to answer questions in examinations.

Researcher: I just picked up something in one of your lessons when you were teaching about acceleration. You used three words when you were describing negative acceleration. You the words deceleration, retardation, and ……………………..

Teacher: Yes, I was talking about negative acceleration. I was teaching velocity time graphs, position time graphs and distance time graphs.

Researcher: You used three terms for negative acceleration

Teacher: Yes I used three terms. You call it retardation when it is going down or you call it deceleration when the speed is going down. As I said negative acceleration can be called deceleration, retardation or declaration.

Researcher: I am not sure about declaration. Can you explain the term declaration?

Teacher: Declaration is the opposite of acceleration. But we normal use deceleration in their textbook. But in my textbook which I used back home they also call it declaration. You can also check. They are all the same or similar. They are all synonyms. They are not anonyms.

Researcher: Thank you for your time

Teacher: sometimes learners find it difficult to use the textbook. You can also refer them at the back of the textbook – the index where words are explained. This can be used in addition to the science dictionary

APPENDIX M

TEACHER B LESSON OBSERVATION TRANSCRIPT

Lesson 1

Teacher: Morning

Learner 1: Morning Mr ND

Teacher: Right we are continuing from where we left. But to (inaudible) to start off. We just want to remind ourselves. There are four points that l gave you which l said we should always refer to. Ye. Can you just mention those for me because we are still applying those points? We did this. Which are those 4 points about the resistors in series and resistors in parallel? Yeah

Learner 2: gives answer but is inaudible

Nd: (repeats learner's answer) Resistors in series are potential dividers. yes, it's very important to understand that. Ey ey last year in grade 10 we did an experiment to prove that. What is the other point about resistors in series before we go on to resistors in parallel? We say resistors in series are potential dividers. What is the other point? Yes

Learner 2: the current .... (inaudible)

Teacher: the current is the same hey. Right. Let's go to resistors in parallel. Eeee Tryon

Learner 3. Talks inaudibly

Teacher: Resistors in parallel are (stops)

Learners chorusing: current dividers

Learner 4: are current dividers ye? .... resistors in parallel are current dividers. Yesterday we did a question eee where we applied that hee. And then eee second point ee about resistors in parallel? Could we have the answer from that side.

Teacher: ... the d in resistors in parallel is the same. Right which means if you put a voltmeter across each of the resistors ee it must give you the same value. Right today we want to refer to division of current by resistors. But now we still maintain the same type of circuit whereby in the circuit we have got resistors in parallel which are in series with other resistors. I am going to use the same question that we used yesterday but today we are looking at ......(inaudible) right by resistors. So in this circuit we said the current, the main current is 2.5. if you refer to you books you will see that the current that we said is flowing through resistor 1 is 2.5A. And these resistors we say they are equal as you can see the value there. Now can you give me the current through there, the current passing through resistor 2. If l says I2, what is the value of that resist, current passing through this? Guys we did this question yesterday. We were doing the same question yesterday. Right now we want us to, without opening the books. Let's look at this. We are saying this is the current passing through this resistor. Right, now we have got resistor 2 and resistor 3. They are both 1amp and 1 amp right? I want you to give me the current that is passing through this resistor without calculating just. Hands up. Yebo

Learner 5: 1.25

Teacher: 1.25 yah. Right. Why this 1.25?

Learners chorus in undertones

Teacher; lets speak up guys. Let's not be shy. It doesn't matter whether you make a mistake. Remember l always say eee we learn by making mistakes.

Learners: eeeh

Teacher: Yes. So .. (inaudible). Eyeee

Learner 6: Resistors connected in parallel are current dividers

Teacher: Resistors connected in, resistors connected in parallel are current dividers. So this main current which comes here is divided, right into two parts, right. The other current passes through resistor 1, resistor 2, the other one passes through resistor 3. But now he says here we get 1.25amps. what are we going to get here?

Learners; 1.25

Teacher: right are you saying its gonna be 1.25amps. Right. Why are they equally?

Learners: speak inaudibly at the same time

Teacher; Because?

Learners: Resistors in parallel are current dividers......

Nd; they are current but do they always divide current into equal values?

(interlude of learners whispering or suggesting reason why)

Teacher: Lets have our hands up. Let's have our hands pliz. Let's have our hands up to ask questions.

Teacher: What l am saying is. We are saying here it's 1.25amps. Can you look at this and here again it's 1.25amps? These values are the same. Do we mean to say that resistors connected in parallel always divide the current into equal values?

Learners: No

Teacher: No. So why are they the same here ?

Learner 7: Because the resistors are equally

Teacher: Because the resistors are equally. So equal resistors will divide the current equally. But if they are not equally they will not divide the current equally. You must know that yeah. Right let me just add here or let me just ask guys. We are saying if the resistors are equally they are going to divide the current equally yeeh? If they are not of the same...... they are not going to divide the current equally. Which, lets say there is a bigger resistor and a smaller resistor, which of the two do you think will have higher current?

Learners speak at the same but one boy says clearly “the one with the bigger resistance”.

Teacher: The one with a bigger resistor, resistance will have a higher current?

Learners: Yes

Teacher: okay

Learner 8: No sir

Teacher: Yee

Learner 8: Opposite

Teacher: You are saying opposite, so which is which now

Learners laugh

Teacher: Yee

Learner 2: the higher the size the less current

Teacher: The higher

Learner 2: the resistor

Teacher: Yeah, the less

Teacher: the less current

Learner 2: the less current

Other learners: No

Teacher: Which, which law can you, can you use to support that

Learners: Ohm’s Law

Teacher: Ohm’s Law?

Teacher: Look, we have talked about Ohm’s law haa. Remember this triangle. V, I, do you agree?

Learners: Yes

Teacher: Right and then we are saying...... We are saying here ohhh eee. We are saying current yeee

Learner: Yes

Teacher: Right. What is the formula there? V over R

Learners: Ya V over R

Teacher: So what relationship between I and R?

Learners: Inversely proportional

Teacher: Inversely proportional yeh. So what does that mean? The bigger the... (pointing at I)

Learners: current

Teacher: the smaller the... (pointing at R)

Learners: resistance

Teacher: Do you get that?

Learners: yeah

Teacher: Right. That's what we should know. So this law will always..... Right now lets proceed and see eee. I want to see guys if you give me the current passing through this resistor, R4.

Learner 6: 2.5

Teacher: 2.5amps again?

Learners: Yes

Teacher: Why?

Teacher: eyy ……, can you explain that to me

Learner 7: tries to explain why but is inaudible.

Teacher: can you start from here (pointing at the two resistors connected in parallel). You can start from here let's see. You add the current for 2 and 3 and then you get the current for this.... OK. So who can elaborate on that yee? Who can add to that, to what she has said?

Teacher: Ehe

Learner 7: if you .... in that part

Teacher: Ehe. In this part

Learner 9: It will go back

Teacher: it will go back and then join yee. So that's why we are adding. So now here we are going to have 2.5amps. right this current is .... can you see that this current is the same . can't they divide, join again. Now you task now is to calculate the potential difference across that, that, that and that in your groups.

(learners then work in pairs to solve the given problem, while the teacher moves around giving assistance)

After sometime one learner goes to the board and writes answer to question.

Teacher: Right you must be specific. Which V are we talking about?

Learners: V1

Teacher: V1. And again in your formula you must be specific about the current. Right, do you see that guys? When you are referring to resistor 1, talk about current passing through resistor 1, talk about current eee voltage across resistor ee 1 and also that resistor. So the Ohm's law must be, is applicable for each resistor. Current, voltage and resistance must all, all refer to the same resistor. You cannot use the current that passes through another resistor to calculate maybe the voltage in another resistor. It doesn't apply. So some are making a mistake by doing that. They have taken the main current for resistor in parallel which is not the main current and use it to calculate the potential difference there. Let's do the correct thing. So.

(followed by silence, while the learner continues to write the rest of the answers to questions)

Teacher: Right, let's analyse this together. Hmm are we happy here?

Learners: Hebo

Teacher: Haaa? There is a no and a yes

Some Learners say yes and others say no

Teacher: You are saying no. What's the problem?

(a lot of mumbling from learners)

Teacher: Can we have order please. Let's have order so that we can proceed. Right guys eee we are looking Ohm's law. I said Ohm's law is very important. We always apply it eee in circuits. Right look. Will you pay attention ….? Right, we are saying here, the potential difference of, the voltage across a resistor. We are saying if we connect a voltmeter here. What will it measure? Then we can use Ohm's law to calculate that if we have got current and resistance ye. So in this case it was easy because all these two were given there, right? Ehh, and l was saying to…. be specific if you are talking about V1 refer to current passing through resistor 1 and resistance. Then we substituted and got 5ohms, 5volts. So there is 5volts there that is measured by that voltmeter. Right. Here l connect another voltmeter here, and another voltmeter there , right. This one will measure eeeh, 1.25 times 1. Those are the values of current and resistance. So you will get 1.25volts. this one will also measure eeeh, 1.25 by 1. That 1.25 is the one that passes through there, that's the current passing through resistor 3, and then the resistance of that resistor is 1, you that volts. Right, and you said at the beginning that voltage across resistors in parallel is the same. You see that is the same, heee. Right, and then if l do this, let's say l take a long wire and put it here, do you see that l will be measuring the voltage of that resistor. If l throw this wire this side, do you see that l will be having the same thing. I am taking this wire there, right, suppose this is my, my voltmeter hee, l am putting it there. I am connecting it there, do you see that wire goes there, right. And then l can put it here. It's the same hee? If l let it go down, it's the same. So l can use one wire to measure the voltage for both by putting the voltmeter, connecting the wires, by connecting the wires of the voltmeter here. I can measure for both. That's why we don't have to repeat this when we are adding. Do you get the point?

Learners: Yes

Teacher: Yes. Just to put here is just to eee move my wire that side but putting them here wil measure that and that at the same time. You don't have to repeat this when you are eeee checking whether the eee these resistors are dividing the voltage.

Lesson 2

Teacher: We continue with the topic eee electricity yeh. Morning ee, l decided that before we continue with power can we just do an experiment to verify ohm's law. We will go back to power, right. This is ee the circuit diagram for the, for the. Can you all pay attention. Quiet. Bonani. Right whenever we are doing an experiment, there are three variables. Right can you just mention those variables?

(learners talk at the same time)

Teacher: Right let's have our hands up......... Hebo

Learner: Independent

Teacher: independent variable. What else?

Learner: Dependant variable

Teacher: Dependant variable?

Learner: Controlled

Nd: controlled variable. Those are the three variables. Those are the three variables eee you must consider. Right in this experiment remember the ohm's law. You know what it says hee. Can you just repeat that law again so that we identify those three variables that we have mentioned? Who can state ohm's law in words? (silence) can l have one of you stating ohm's law in words? Eee. let's have one of you stating ohm's law in words. Remember l said those laws are there in your formula sheet. Just, what you are supposed to do is just say them in words. Say that formula in, in words. You have the formula; you know the formula. So if you cannot remember the law in words, just write down that formula and then try to say it in words. Aaah ….

Learner: sir the current passing through a resistor is proportional to voltage across a resistor provided the temperature remains constant

Teacher: provided the temperature remains constant yeh?

Teacher: Right, can we proceed. He said, he said eee, the current passing through the resistor is directly proportional to the voltage across the resistor provided the temperature of the resistor remains constant. Right in such a case, we say that resistor is ohmic resistor. Why ohmic? Because it obeys ohm's law. Right, which resistor is ohmic? Is the one that obeys ohm's law. In other words, we mean to say, eeeh, the value of the resistance remains constant. Right. What can change the value of the resistance is the temperature of the resistor. So if the temperature of the resistor increases i resistance of the substance of the resistor also increases. But in this case when we are talking about ohmic resistor, we mean the resistance remains constant. Which means is not affected by the change. That's why we put that statement to say provided the temperature of the resistor remains what, constant. Which means the resistance won't be affected by eeeh, the resistance of the circuit remains constant. Right, now eeh let's .... to that law down and then we underline the variables. And then after that we can state which one is independent, which one is dependant and so on in your experiment. Right, so we are saying current passing through the resistor is directly proportional to the potential difference or voltage across the resistor provided the temperature of the resistor remains constant. Now can you give me the variables there so that l underlines them from there we give them names. The variables in this law. (silence)

Teacher: ……., which are the variables there?

Learner: Current

Teacher: Current right. What else? Yes …..

Learner: Temperature

Teacher: Temperature. Okay. What else? Yes

Learner: Voltage

Teacher: The voltage. Those are the three variables yeh? Right. Now which one do you think is independent here?

Learner: Voltage

Teacher: The voltage is independent yeeh? So independent variable you is voltage, yeh? Then eeeh this is the one that we fix yeh? So the dependant will be what?

Learner: Current

Nd: Current. Right. Dependant will be what? Current. So you fix what? The voltage then the current will depend on your, on the voltage that you fix yeh. And then the control is what?

Learners: Temperature

Teacher: Control is temperature. By control we mean it doesn't change yeh? Control is temperature. It doesn't change. Right now we gave our three variables now. So the circuit diagram is there on the board, right. We are saying here from the positive you connect what, to the ammeter. From the ammeter, first of all you are connecting the main circuit. You are saying from positive to the ammeter, from the ammeter to the resistor. I will put a bulb because l doesn't have a suitable resistor here. But a bulb is not ohmic resistor because the temperature will increase. So every time you take a reading you switch off to avoid what, increase in temperature. So that you are controlling what your temperature there on the resistor. Your resistor is the bulb. So control that eeeh temperature by eeeh connecting it the bulb for a short time, disconnecting it then after taking the reading. When you are ready to take a second reading, you connect again, take the reading disconnect yeh, to avoid the increase in temperature otherwise it won't come out. So after connecting the bulb there, you go you take a wire and then you connect it to the cell. Right and then remember eeeh the voltmeter is always connected across the, the resistor. Right the ammeter is always in series because ammeter is just counting how many charges are passing it, eeeh that point per second. (recording stopped for a short interlude)

Teacher: We have to connect in series with the...

Learner: resistor

Teacher: then this one is across the resistor according to what Anani said. That's why we are connecting the voltmeter across the
Learners: Resistor

Teacher: The resistor. you see we are connecting according to ohm's law. Now can we make eeeh three groups. Let's make three groups. We do this circuit. You must have your table of values designed. Remember we said you have got the dependant and independent, the controlled doesn't change you don't have to include here. Maybe you can do that, put room temperature at least room temperature .... so let's have one group here, another one at the back there, another one there.

(learners proceed to carry out experiment in three groups as directed. Teacher moves around the groups checking and giving assistance)

(After the experiment, a class discussion)

Teacher: Let have a table from one of the groups. (learner hands a paper with a table of results)

(teacher draws a table of results on the board, proceeds to fill in the results as given by one of the learners)

Teacher: Let's look at those values hey. Eeeh, those, that's the table of results hey. Eeeh but by just looking at this you can tell us what happens to, to your current just by looking at this. Can you all look at the values and try to.... state what is happening to current as voltage increase.

Learner: The higher the voltage, the higher the current

Teacher: The higher the voltage, the higher the

Learner: Current

Teacher: So you mean to say? In another words, who can say that in another, another words?

Learner: (says something but is not audible)

Teacher: Current also increases, right and then eeh there are some terms in physics that we use

Learner: Directly proportional

Teacher: Directly proportional. Which is directly proportional to the other?

Learner: Voltage is directly proportional to current.

Teacher: Yes, ya and then for all this l saw in other table they putting same temperature, same temperature, same temperature yeh. But the temperature we are using is room temperature yeh

Learners: Yes

Teacher: We are saying we are using the temperature of the wire at room temperature. That’s why we were disconnecting to avoid increase in temperature of the resistor. Otherwise we wouldn’t be , we wouldn’t be talking about ohm’s law. Right, eee, interpretation of the results, you draw your graph of voltage against what current hey?

Learners: yeeh

Teacher: And then you can calculate your resistance. remember resistance, resistance using a graph is the gradient of the graph yeh. The resistance is the gradient of the graph. So now eeeh, can we in our groups just write a short report of what we did starting from the aim until you go to the conclusion. Eeeh, if you can put that at the back of your book, because l wants to continue with power on this side. So that’s the end of the lesson. Thank you.

Lesson 3

Teacher: Eeeh, let’s pay attention. Ok, r..., l think l mentioned that eeeh that somebody will come and observe our, our lesson. He chose three lessons eeh and there is another guy who is going to come and observe us again in energy and change yeh. So make me pass. Right eeh, eeh, the topic is electricity as you know, and today we are just covering parallel resistors in series with other resistors yeh? In this case l mean to say these are parallel resistors yeh?

Learners: Yes

Teacher: But there are series with other resistors it can be eeh two resistors in parallel with maybe one resistor in series them. Remember series means one after the other. So these are in parallel but they are in series with this one and that one, right. And our questions here say calculate the current follow, flowing eeh through the cell. Right that current flowing through the cell is the main current or the total current. Right, this is the total current. And remember we said when we are calculating the total current what do we use? Which law do we use to calculate the current?

Learners: Ohm’s law

Teacher: Ohm’s law in that case yeh? Right we are given eeh, eeh the voltage there but now which resistor or resistance do we use there? (silence) Remember we are calculating the total current. Current that passes, passes through the cell is the total current yeh?

Learners: Yeah

Teacher: Right. And ohm’s law, who can give us ohm’s law? Yes?

Learner says the answer while the teacher repeats the answer as he writes it on the board

Teacher: The. Can you speak louder than that?

Learner: the current is v times R.

Teacher: Right, where v equals the potential difference across th cell. Right, in this case for the total eeh, eeh, the total eeh current we are going to use the total voltage which is the total voltage across the cell yeh?

Learners: Yes

Teacher: And then this is the total current that we are going to use. And In this case this resistance l want you to tell me which resistance are we going to use there. (silence)

Teacher: Right, if l can write this, maybe l can put it this way (writes on the board), is equals to I multiplied by what (silence). Its now better. So what resistance are we going to use there?

Learner: Total

Teacher: Total. So how do you find the total resistance, resistance there?

Learner says something inaudible

Teacher: First what?

Learner: (inaudible)

Teacher: Okay, l find the effective resistance of these resistors in parallel, then from there what do l do?

Learner: (inaudible)

Teacher: I add the parallel eeh, ok with the, that resistance and that resistance right. Then l has my total resistance in the circuit. This is the one that l am going to use there yeh to find the total current yeh. And then this voltage or potential difference will be the potential difference there across what? The cell yeh? Right, so let’s do that. Who can do that for us? Put your data and then work the problem and then we will discuss together.

(learners work out the problem with assistance from the teacher, then one learner goes to the board to write her working of the solution on the board)

Learner: Should l write the data?

Teacher: Ya

(learner proceeds to write the problem on the board)

Teacher: Now from there data is there we do we go? Because we don’t have eeh the total eeh, eeh resistance, so the first is to solve what? The resistors in parallel hee? Right, and then from there we add all as we have said to find the total resistance before we use ohm's law. So let's do that

(learner proceeds to work out the solution on the board)

Teacher: All right from there eeh anything, any comments there? No comment everything is correct?

Learners: Yes

Teacher: Right but Aaah, l have got two things to mention on, for example here, what is missing in this data? .... Look at the data. Let's say, look at this. What is missing there?

Learners: Chorus something inaudible

Teacher: What?

Learner: t

Teacher: t?

Learner: (inaudible)

Teacher: Ok. The what? T?

Learner: Symbol

Teacher: Symbol for what?

Learner: Voltage

Teacher: Voltage? Symbol for voltage is there.

Learner: v

Teacher: Which v?

Learner: small v

Teacher: Hayi hayi guys hey. There is something missing. Let's go to this one. What is missing in this one?

Learners: Ohms

Teacher: Ohms, the units hee?

Learners: Yes

Teacher: Every physical quantity in physics must have the units. Right, right, ok, ok

Learner: says something inaudible, the whole class laughs

Teacher: Right, right. Let’s continue, now did you understand this part? (silence) That’s why l was asking ukuthi do you have any comment guys, eeh, eeh. Do you have any comment? That’s why l was asking that. You must show all the working following the formula that is written there. This might be true, but eeh, you must show it there how you arrive to this part. Right, who can tell us what to do here if you follow the formula? There are two numbers here, right? Let’s do this hey? What do l do here? What is the eeh, resistance eeh, R2?

Learners: 1

Teacher: You must show it. 1 divided by what?

Learners: 1

Teacher: By 1 hey? And this one by

Learners: 1

Teacher: This one is 1 over (writes 1). Understand? Right, common denominator there is what?

Learners: It’s 1

Teacher: It’s one hey? Right, and then 1 into 1 is 1 times 1 plus 1 is 1 over R parallel hey? Then which means, eeh, 1 over R parallel is equal to 2 over 1. If you invert this hey? Right eeh, we have 1 over, R parallel is equal to 1 over 2, which is equal to zero point

Learners: 5

Teacher: Ohms. So she was correct. Right, now thi is only this part. She has solved this part such that the circuit remains like this(draws a circuit diagram with three resistors in series). You see this is our new circuit after finding this R parallel which is equal to 0.5ohms. this one remains 1.5 we haven’t touched it, and this one is

Learners: 2

Teacher: Is 2 ohms. Then from there, from there what do we do? Remember we want to find the total resistance hey? So what do we do there?

Learner: (says something inaudible)

Teacher: R t, speak up

Learner: R1

Teacher: R 1

Learners: plus R 4

Teacher: plus R 4

Learner: Rp

Teacher: Plus

Learners: R 3

Teacher: Yes, and then what do we get there? Is 2 ohms plus 0.5 ohms plus Learners: 1.5

Teacher: 1.5 ohms. Then our total resistance will be what?

Learners: 4

Teacher: 4 ohms, hey?

Learners: mmh

Teacher: Right, now the question wanted us to calculate, eeh, total current. Can you close that door please? Total current which is It is equal to I, where now Vt is equal to I(then writes R on board so that it reads VT = ITR). Then what is our total voltage

Learners: 10

Teacher: Right is equal to I we don't know this one multiplied by 4. That's our, our total resistance, hey?

(proceeds to calculate the main current flowing through the battery/circuit and gets 2.5 A)