Exploring effects of incorporating English Language in Secondary School Science Education: A Case of Secondary School Physical Sciences Learners in Mpumalanga Province

BY

ALFRED SIPHO HLABANE

Submitted in accordance with the requirements for the degree of

MASTERS OF EDUCATION

with specialisation in

NATURAL SCIENCE EDUCATION

at the

UNIVERSITY OF SOUTH AFRICA

SUPERVISOR: PROF. N. NKOPODI

FEBRUARY 2014

DECLARATION

I declare that **Exploring effects of incorporating English Language in Secondary School Science Education: A Case of Secondary School Physical Sciences Learners in Mpumalanga Province** is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

SIGNATURE DATE

(Mr) AS Hlabane

Student Number: 4458-9689

ACKNOWLEDGEMENTS

I wish to express my gratitude to the following:

- The almighty for being my shepherd. “I will always remain indebted to You my Lord for all the days of my life”.
- My mother, Victoria Hlabane for being the pillar of my strength. I am who I am today because of her full support for my dreams.
- My Wife Zanele and my children, Koketso and Thabo for their undying love even in difficult situations.
- Prof Nkopodi for his kind heart and understanding; this journey would not have been achieved without his professional guidance.
- My colleagues for their understanding when I was asking for their time; may the good Lord bless them abundantly.
- Learners “thank you for your participation”; may the God of Israel reward you for all your efforts.
- Mr Obu for his support during the pilot study.

DEDICATION

This study is dedicated my late brother Thabo Thompson Hlabane.

ABSTRACT

This study investigated the effects of incorporating English language teaching in Physical Sciences education. The sample was selected from Physical Sciences Grade 10 learners in a school in Mpumalanga Province and comprised an experimental group who were taught through a workbook that incorporated language teaching in science lessons and a control group who were taught via the normal textbook prescribed by the Department of Basic Education. Pre- and post-tests were administered to both groups and a sample of learners participated in a focus group interview. Two educators were also individually interviewed.

The results revealed that incorporating language teaching in science lessons not only improves learners' academic performance but also their comprehension skills, and encouraged the application of learner-centred methods of teaching. The study recommends that Physical Sciences textbooks include English language activities with the view of incorporating language teaching in Physical Sciences content lessons.

Key Terms: Science Education, Language of Science, First Additional Language, English language, Second Language, Physical Sciences, Language of Learning Teaching, Medium of instruction.

ABREVIATION AND ACRONYMS

ANA : Annual National Assessment

BICS : Basic Interpersonal Communication Skills

CALP : Cognitive Academic Language Proficiency

CAPS : Curriculum and Assessment Policy Statement

DBE : Department of Basic Education

DOE : Department of Education

ESL : English Second Language

FAL : First Additional Language

FET : Further Education and Training

GET : General Education and Training

L2 : Second Language

LEP : Limited English Proficiency

LoLT : Language of Learning and Teaching

TIMSS: Third International Mathematics and Science Study

TABLE OF CONTENTS

LIST OF TABLES **Page**

LIST OF FIGURES **Page**

LIST OF APPENDICES **Page**

CHAPTER 1

ORIENTATION TO THE STUDY

1.1 INTRODUCTION AND BACKGROUND

Reading, writing, hearing and, especially talking science is a large part of what professional scientists do. Along with some time spent in practical work, this is mostly what science teachers and pupils do (Wellington and Osborne, 2001: 4). These skills, especially reading and writing about science are of great importance since learners are expected to read and answer question papers when writing examinations.

Most learners when you engage with them in Physical Sciences classroom they look as if they understand what is taught. As I do activities with them, they score good marks. However when the problems are presented in the different context from what they have learned in class, most of them fail to interpret the new context.

For example, in the conservation of momentum, learners are taught how to use the formula for conservation of momentum in different situations. However during examinations, most of them fail to interpret the questions in the new context and therefore they fail to apply the knowledge and skills learned about conservation of momentum. This indicates that these learners lack the skills of reading and comprehending academic material. Most of our learners today do not fail because they do not know the content, but they fail because they lack the skills of interpreting what is asked in the question papers. This is an indication that the gap is on proficiency in the Language of learning and teaching, especially on the use of language for academic purpose.

It is imperative for science teachers to be aware that language teaching in science education is important and cannot be ignored. As a science teacher, I have observed my learners struggle to comprehend questions and I always have to intervene by code switching in order to make them understand. The major issue is that science on its own has its own technical terms that most learners do not encounter in their daily lives. This means that embedding some language strategies in the science classroom is an activity that must not be neglected.

Jordan and Van Rooyen (2009:271) assert that “language for academic purposes is an important concept, not always recognized and developed within education system”. This is especially important to the majority of learners in South Africa who learn science in English as a second language which poses serious concerns. Teaching science to English second language learners requires a specific pedagogy which supports learners in developing both subject matter knowledge and language skills which are both vehicles for acquiring knowledge in the discipline.

Wellington and Osborne (2001: 5) further state that “science education involves dealing with familiar words like energy ‘and giving them new meanings in new contexts. Equally many of the ‘naming’ words of our lives have been commandeered by science. Consider ‘element’, ‘conductor’, ‘cell’, ‘field’, ‘circuit’, and ‘compound’. This is made worse because many terms in science are metaphors. For example a field in science is not really a field. Another category of language is what science teachers call ‘the language of secondary education’. The list includes modify, compare, evaluate, hypothesize, infer, recapitulate and so on. These are words used by science teachers and exam papers but rarely heard in playgrounds, in pubs or football matches”. This indicates that learning science is even more difficult for learners who learn science in a second language especially in South Africa where English dominates as the language of instruction.

Looking at the South African background, political changes during the past two decades have placed the language issue at universities and secondary schools under the spotlight. The language of the former South African government was predominantly Afrikaans which is a language of Dutch origin, spoken mostly by white Afrikaners and Cape Coloured communities. With the advent of democracy in 1994, it was decided to recognise eleven official languages. English is becoming the *lingua franca* by default, but not by official policy (Probyn, 2005:1-2). This indicates that English still dominates as the language of teaching and learning in South Africa.

Setati (2011: 9) purports that “the Constitution of South Africa states that schools can choose to educate learners in any one of the eleven official languages. Nevertheless, most schools have adopted English as the language of learning and teaching, despite the fact that the home language for most learners and educators is not English”. This poses as a challenge in the learning of science as a discipline with its own specialised vocabulary.

Research confirms that language competence and proficiency are central to educational success (Jordan and Van Rooyen, 2009:5). However it is a recognised problem that learners have to master science via a second language in South Africa. For these learners, the problem becomes twofold. Firstly; understanding the language of teaching and learning, and secondly understanding the language of science which has a rich vocabulary.

A report on the Language of Teaching and Learning published by the Department of Basic Education (DBE) also confirms that English is still the dominating language of teaching and learning to the majority of learners in South Africa (DBE, 2010:12-13). The figure below indicates learner percentages by language of learning and teaching:

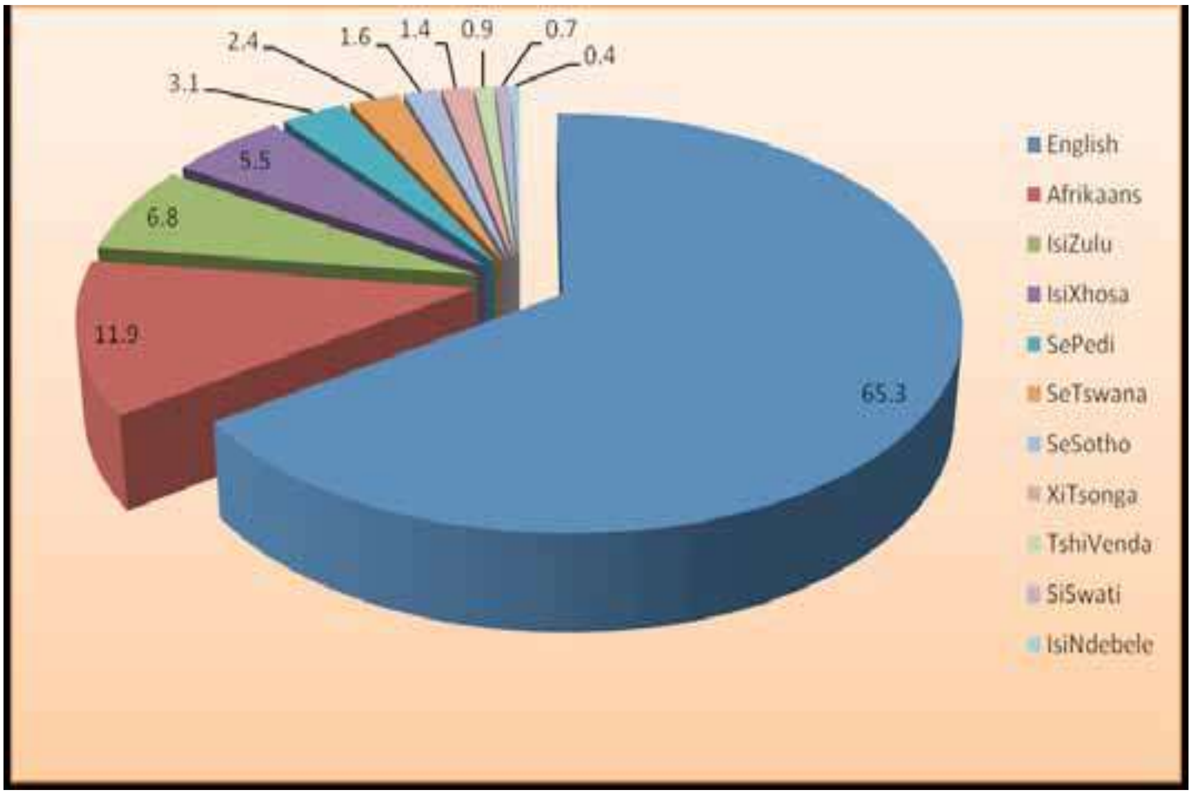


Figure 1.1: Percentage of learners by language of learning and teaching: 2007 (SOURCE: DBE 2010)

English is the home language of less than 10% of the population in South Africa. However Figure 1.1 indicates that it is the language of teaching and learning to 65% of the South African learner population. The language of teaching and learning for the first three grades in South Africa is predominantly mother tongue, but in secondary schools, 80% percent of learners use English as the language of teaching and learning (DBE, 2010: 12-16).

The task team appointed by the Minister of Basic Education, Mrs Angie Motshega, to review the implementation of NCS found that there are challenges to using English as the language of learning and teaching (DBE, 2009:39-42). One of the challenges was that South African children fared particularly poorly in local and international testing in Grades 3, 6 and 8, especially in the 1999 and 2003 Trends in International Mathematics and Science Study (TIMSS) where South Africa came last in mathematics and science (TIMSS, 1999).

Some of the reasons identified were that most provinces introduce English as a subject only in Grade 3 and not in Grade 1 as suggested in the policy statement policy. In the intermediate phase there were eight subjects and seven of them have to be learned in English. The recommendation made by the task team was that the importance of learning English in the curriculum from Grade 1 must be underscored by introducing a fourth subject in the foundation phase, namely English as a first additional language. However if the problem is only addressed in the foundation phase, most learners will still face language issues in other phases, especially in FET where one of the subjects is Physical Sciences.

The results of the 1999 Trends in Mathematics and Science Study were released by the Human Sciences Research Council (HSRC). The results show that South Africa still lags behind other countries in the study of mathematics and science (HSRC, 2002:2). In addition the Grade 6 National Systematic Evaluation, a survey commissioned by the National Department of Education and carried out by the HSRC in late 2004, found that a vast majority of South Africa’s Grade 6 learners are failing to achieve the expected outcomes in natural science, language and mathematics. When English as a LoLT poses an obstacle to the acquisition of appropriate knowledge it impacts on the conceptualisation of science, and it becomes imperative to research the magnitude of the problem and how it is manifested (Setati: 2011: 6).

Logan & Hazel, (1999) in Van Staden (2010: 10) also agrees that “second language students perform poorly in theoretical exams where higher order cognitive skills such as application and analysis were tested. In fact students generally find it difficult to advance from the abstract to the concrete. To cope, it is argued, they rely on rote learning and memorisation instead of striving to understand the content. While English second language students may be highly motivated to achieve, they however, failed to comprehend scientific written text when delivered as spoken text by the lecturer”.

Therefore this study was designed to investigate the effects of incorporating English language teaching in the science classroom using a case study. It is hoped that incorporating language teaching with science will assist in dealing with the language-related issues mentioned above and improve academic performance in Physical Sciences.

1.2 RESEARCH PROBLEM

Several learning theories support an interdisciplinary approach. Multiple intelligence theory describes eight intelligences (linguistic, musical, logical-mathematical, spatial, bodily-kinaesthetic, interpersonal, intrapersonal, and naturalistic) which also provides a foundation for subject integration, by encouraging learners to search for meaning and problem solving across a wide range of subject area (Woolfolk, 2007:113). Constructivist theorists suggest that education is inherently interdisciplinary and quality learning only occurs when students and teachers have opportunities to consider, analyse, interpret, and reflect on big ideas and concepts (Richards and Shea, 2006: 2).In this study, science and language teaching are incorporated in the science classroom, which is considered an interdisciplinary approach.

The problem referred to above can be addressed by the following questions:

- What is the importance of incorporating English language teaching in science lessons?
- What are the appropriate language pedagogical practices that can be used in science classrooms that incorporate English language teaching and science?
- Can English language teaching in science classrooms be used as a tool to improve academic performance and to promote scientific literacy?

1.3 AIMS AND OBJECTIVES OF THE STUDY

The general aim of this study is to investigate the role of incorporating English language teaching in science lessons with the aim of improving academic performance and scientific literacy. The specific aim is to identify the appropriate language pedagogical practices that can be used in science classrooms.

1.4 SIGNIFICANCE OF THE STUDY

Recent history has demonstrated the potential of science and technology to improve the quality of people's lives. However learners in South Africa perform poorly in mathematics and science when compared to other developing countries. Although concerted efforts have been made to improve the quality of teaching and learning in science subjects in South Africa, there has never been significant improvement.

Reports from the Department of Basic Education show that mathematics and Physical Sciences are the lowest scoring subjects in the national senior certificate results. For instance, the national pass rate percentages for Physical Sciences in 2009, 2010, 2011, and 2012 were 36.8%, 47.8%, 53.4%, and 61.3% respectively (DBE, 2012:5). Although there has been some improvement, the pass rate has never reached 70%. This is not good for a country which needs science professionals for the development of its economy. The table 5.1 below adapted from DBE (2012:5) indicates the performance of Grade 12 learners in selected subjects for Grade 12:

Table 1.1: Grade 12 performance in selected subjects from 2009 to 2012

Subjects	2009			2010			2011			2012		
	WROTE	Achieved 30% and above	% achieved	WROTE	Achieved 30% and above	% achieved	WROTE	Achieved 30% and above	% achieved	WROTE	Achieved 30% and above	% achieved
Accounting	174347	107156	61.5	160991	101093	62.8	137903	84972	61.6	134978	88508	65.6
Agricultural sciences	90136	46597	51.7	85523	53573	62.6	77719	55404	71.3	78148	57571	73.7
Business studies	206553	140469	71.9	200795	142742	71.1	187677	147559	78.6	195507	151237	77.4
Economics	153522	109955	71.6	147289	110824	75.2	133358	85411	64.0	134369	97842	72.8
English FAL	486755	451428	92.7	449080	424392	94.5	414480	398740	96.2	420039	410999	97.8
Geography	215120	155481	72.3	209854	145187	69.2	199248	139405	70.0	213735	162046	75.8
History	90054	65025	72.2	87675	66428	75.8	85928	65239	75.9	94489	81265	86.0
Life sciences	298663	195652	65.5	285496	212895	74.6	264819	193946	73.2	278412	193593	69.5
Mathematical literacy	277677	207326	74.7	280836	241576	86.0	275380	236548	85.9	291341	254611	87.4
Mathematics	290407	133505	46.0	263034	124749	47.4	224635	104033	46.3	225874	121970	54.0
Physical sciences	220882	81356	36.8	205364	98260	47.8	180585	96441	53.4	179194	109918	61.3

The results indicate that Physical Science is one of the three lowest scoring subjects along with mathematics and accounting. The number of learners taking Physical Sciences has also dropped from 220882 in 2009 to 109918 in 2012. This is an enrolment drop of more than 50%. Although there has been some improvement, the results indicate that there is still a problem with the results in Physical Sciences; in spite of more than 90% of learners passing English First Additional Language, the pass rate for Physical Sciences has still not exceeded 70% since 2009.

The TIMSS results from 1995 to 2003 which reflected the lowest scores in science for South Africa, Botswana, and Ghana also confirmed that as a country we are doing well in science education. It is estimated that the developing countries of Africa need at least 200 scientists per one million individuals for effective industrial development. That means African developing countries including South Africa need to produce more learners majoring in science subjects in order to be accepted for science and engineering degrees at universities. This cannot happen if science subjects are still the lowest scoring subjects in Grade 12 results.

Science educators need to be aware that the language of science is a barrier to learning for the majority of learners in the country. Learning and teaching support materials that incorporate language teaching in science classrooms must therefore also be prioritised and designed. The outcomes of this study contribute to further research that offer solutions to the challenges that learners encounter in dealing with language issues in science education. It is hoped that poor academic performance in science will be minimised if learners understand the language of science.

The researcher would like to acknowledge the concerted efforts that the Department of Basic Education has made in addressing the language disparity in our education system. Making textbooks available is one of the things that the Department has ensured and every learner in South Africa has been given a quality textbook since the introduction of Curriculum and Assessment Policy Statement (CAPS), although there were some challenges in Limpopo Province. The challenge is that as educators we need to make sure that learners are able to utilise the textbooks to their benefit.

The introduction of a fourth subject in the Foundation phase, namely English First Additional Language shows that the Department acknowledges the language of teaching and learning as one of the major problems in our education system. However, it is evident that most of the learners still struggle to use English for academic purposes even if they are able to express themselves well in English. Lastly, the introduction of Annual National Assessment (ANA) also indicates that efforts are made to improve literacy and numeracy rates in the South African education system.

The ANA results will set a bench mark to assess if our education system is on the right track or not. Previously, the only instruments used to measure the quality of our education system were the Grade 12 results. The introduction of ANA will assist in identifying challenges in the lower grades. However, it is important that after getting the results we act on them and this study sort of provide solutions to some of these problems.

1.5 LIMITATIONS OF THE STUDY

Many aspects of language are not discussed which includes writing in the science classroom, discussions in the science classroom, and the concept of visual literacy. These need to be addressed. The focus of this study is on reading, especially reading for academic purpose. The study also pays more attention on text-based methods of teaching and used comprehension-based approach although there are many language teaching approaches. There is a need to also investigate other language teaching approaches and incorporate them in science education.

1.6 DEMARCATION OF THE STUDY

The study involved three phases. The first phase involved the development of a workbook that incorporates the topic of mechanics in Physical Sciences and teaching English as a first additional language. In the English component the focus was on reading and comprehension in the science classroom. The contents of the workbook included notes, daily Physical Science activities, and an English activity for each unit. The workbook was designed in a way that allows learners to read and write extensively in a scientific context.

Reading and writing scientific material should enable learners to synthesise the technical and special vocabulary of science as a subject. In other words, it should promote scientific literacy in the topic and thus enhance cognitive development skills
In the second phase of the study the workbook was piloted. Learners who were doing Physical Sciences in Grade 10 were taught with the use of the workbook. A pre-test on the topic concerned was administered there after the learners were taught though the workbook. The post-test which is identical to the pre-test was administered at the end of lessons.

In the third phase, the final and improved workbook was implemented in the classroom with learners. The same procedures that were followed in the pilot study were implemented but this time there were two groups of learners. The first group was taught using the workbook while the second group was taught with the textbook they normally use in class. Both groups were given the pre-test before and after the teaching of the topic; both groups of learners were given the post-test. The marks for the groups were then compared.

1.7 DEFINITION OF CONCEPTS

1.7.1 Language of Learning and Teaching (LOLT)

The Department of Basic Education (2010:3) defines the language of learning and teaching as the language medium through which learning and teaching, including assessment takes place.

1.7.2 Physical Sciences

The Department of Education (2003:9) defines Physical Sciences (also known as science) as the subject that focuses on investigating physical and chemical phenomena through scientific inquiry by applying scientific models, theories, and laws and seeks to explain and predict events in our physical environment. The subject also deals with society's desire to understand how the physical environment works, how to benefit from it, and how to care for it responsibly. In brief, it is a combination of physics and chemistry.

1.7.3 Mechanics

Broster and James (2005:22) define mechanics as the study of the motion of objects, as well as of forces and how they affect motion. This makes the topic relevant to the behaviour of large objects in space such as planets, stars, and galaxies, as well as to the smallest objects such as electrons and atoms.

1.7.4 Home language

The Department of Basic Education (2010: 3) defines home language as the language that is most frequently spoken at home by a learner.

1.7.5 Language proficiency

According to the DBE (2010) language proficiency is the level of competency at which an individual is able to use a language for both basic communication tasks and academic purposes.

1.7.6 African language

African language refers to South Africa's nine official languages namely: isiNdebele, isiXhosa, isiZulu, Sepedi, Sesotho, Setswana, SiSwati, Tshivenda and Xitsonga (DBE, 2010).

1.7.7 First additional language (FAL)

According to the DBE (2010: 30) first additional language is a compulsory language subject that learners have to study.

1.8 DIVISION OF CHAPTERS

Chapter One introduces the topic under discussion, the research problem, the aims and objectives of the study, the significance of the study, and the demarcation of the study. Chapter Two presents the literary review and explains the conceptual framework of the importance of incorporating English language teaching in science classrooms.

The research design and method of the study are discussed in Chapter Three. Questions for the pre- and post- test and the process of developing the workbook are also discussed. Chapter Four discusses the data presentation, interpretation, and analysis. This includes transcripts from videos and the results of the pre- and post-tests. Lastly Chapter Five discusses conclusions, recommendations, and suggestion for possible further research.

CHAPTER TWO
LITERATURE REVIEW

2.1 INTRODUCTION

Reading ability influences learner success in all areas of academic learning. It is a fact that learners can only develop their understanding of science knowledge by reading textbooks, articles, and other research material. It does not matter whether the learners are English first language or second language speakers; they all need to develop reading proficiency for academic success.

This chapter firstly explores the meaning of language and its impact on learning in the context of science teaching. Secondly, the nature of the language of science is discussed as well as different language teaching approaches and the importance of incorporating the latter in science classroom. An overview of the Physical Sciences curriculum according to CAPS is given and lastly, the conceptual framework of the study is discussed.

2.2 LANGUAGE AND ITS IMPORTANCE IN LEARNING

According to the Department of Basic Education (2011:14):

> Language is defined as a tool for thought and communication. It is also a cultural and aesthetic means commonly shared among people to make better sense of the world they live in. Learning to use language effectively enables learners to acquire knowledge, to express their identity, feelings and ideas, to interact with others, and to manage their world. It also provides learners with a rich, powerful and deeply rooted set of images and ideas that can be used to make their world other than it is; better and clearer than it is. It is through language that cultural diversity and social relations are expressed and constructed, and it is through language that such constructions can be altered, broadened and refined.

The implication of the above is that acquiring language skills gives learners an opportunity to learn how to learn. According to the definition of language as a tool of thought, acquiring the necessary language skills gives learners an opportunity to acquire knowledge, specifically science knowledge. This implies that the discourse around science education discourse cannot be separated from language skills.

The DBE (2011:14) further suggests that First Additional Language level assumes that learners do not necessarily have any knowledge of the language when they arrive at school. The focus in the first few years of school is on developing learners' ability to understand and speak the language-basic interpersonal communication skills. In Grades 2 and 3 learners start to build literacy on this oral foundation. They also apply the literacy skills they have already learned in their Home Language in the Intermediate and Senior Phases, learners continue to strengthen their listening, speaking, reading and writing skills. At this stage majority of children are learning through the medium of their First Additional Language, English, and should be getting more exposure to it. Greater emphasis is therefore placed on using the First Additional Language for the purposes of thinking and reasoning. This enables learners to develop their cognitive academic skills, which they need to study subjects like Science in English. They also engage more with literary texts and begin to develop aesthetic and imaginative ability in their Additional Language. By the time learners enter Grade 10, they should be reasonably proficient in their First Additional Language with regard to both interpersonal and cognitive academic skills. However, the reality is that many learners still cannot communicate well in their Additional Language at this stage.

The above implications indicate that if learners have problems with the language of teaching and learning, then learning in other disciplines will be difficult since they are not proficient in the language of learning and Teaching. This means that for learners who are learning science in the second language, it will be like learning two languages since science is a discipline with its own language.

Proponents of second language pedagogy concur with the Department of Basic Education insofar as proficiency in second language is a two way process: “face to face communication known as basic contextual language skills and academic uses of language such as reading and writing about school subject known as academic English” (Woolfolk, 2007:185). However, secondary school English teaching mainly focuses on teaching learners contextual basic English language skills; learning English for academic use is not emphasised. As a result, most learners underperform due to lack of proficiency in academic language skills.

Probyn (2005:6) argues that “for many township and rural learners in South Africa, the oral language of the school classroom beyond the first three grades is frequently their home language whereas the language of reading and writing and assessment at school is English”. Bridging the gap and acquiring not only the proficiency required for academic learning and meaningful engagement with the curriculum is difficult for many learners. Learning English only for basic contextual use is insufficient; there is a need to learn English for the purposes of understanding academic subjects like Physical Sciences.

These challenges were also confirmed by the report of the Third International Mathematics and Science Study (TIMSS) conducted in 1999 in which the findings show that the majority of South African pupils could not communicate scientific conclusions in the language used for tests (i.e. English and Afrikaans which were the mediums of instructions and also the languages currently used for matriculation examinations). In particular, pupils who study mathematics and science in a second language tend to have difficulties articulating answers to open- ended questions and apparently have trouble comprehending several of the questions (Probyn, 2005:1857). This indicates that lack of proficiency in the LoLT is one of the contributing factors for poor performance in mathematics and science in South Africa.

2.3 THE NATURE OF SCIENTIFIC LANGUAGE

School science tends to be viewed mainly as a practical subject although its teaching involves practical work as well as the use of language (Wellington & Osborne 2001:3). It is a form of culture with its own language. One obvious feature of the nature of scientific language is that it contains technical words that rarely occur in children's everyday informal spoken interactions (Fang, 2006:493).

Words like 'force', 'velocity', 'displacement' and 'gravity' for example, are some of the technical terms in physics textbooks that most learners are unfamiliar with. These terms are important for accurately conveying the specialised knowledge of science and distinguishing this discipline from others. Paying attention to language in the classroom is therefore of great importance for effective vocabulary acquisition.

Oyoo (2005:2) maintains that science words form the distinctive body of concepts which mark out science from other subjects, or different school science subjects from each other for example physics as distinct from biology or chemistry. Wellington and Osborne (2001:1) further state that one of the major difficulties in learning science is learning the language of science. However, this is not a message that has reached the science teaching profession. The science profession needs to be aware that learning the language needs to be a major part of science education, and that language is a major barrier to the learning of science.

Prophet and Badebe (2006:239) emphasise that to learn in the domain of science, the learner has to acquire a new language and without this language, understanding cannot be achieved. This indicates that for the second language learner two major learning difficulties sit side by side and interfere with each other: learning to use the language of instruction, commonly English, at the level required for learning academic content, and learning to use the language of science in order to decipher what is being said.

Philips and Norris (2009:314) likewise confirm that reading and writing are essential to science whilst Tenopir and King (2004) convincingly demonstrate the importance of reading to science. According to Tenopir and King the scientists they surveyed read a great deal; on average 553 hours per year of their total work time. The award-winning and high achieving scientists read more than the average. Furthermore, when communication activities of speaking and writing were included in the study, they discovered that scientists spent on average 58% of total work time in communication. Learners in the classroom should be taught to do what professional scientist do, which implies that reading and writing in a scientific manner must be part and parcel of classroom teaching.

The Department of Basic Education’s (DBE) Curriculum and Assessment Policy Statement (CAPS) for Physical Sciences (2011:14) suggests that teachers of Physical Sciences should be aware that they are also engaged in teaching language across the curriculum. This is particularly important for learners for whom the Language of Learning and Teaching (LOLT) is not their home language. It is important to provide learners with opportunities to develop and improve their language skills in the context of learning Physical Sciences. It will therefore be critical to afford learners opportunities to read scientific texts, to write reports, paragraphs and short essays as part of the assessment, especially (but not only) in the informal assessments for learning. This indicates that incorporating language strategies in science classrooms is important.

According to Farrel and Ventura (2010: 243) in science education, interest in word understanding first gained momentum in the early 1970s when Gardner (1972) conducted an analysis of the vocabulary skills of students attending secondary school. As part of his involvement in the Australian Science Education Project, Gardner tested the understanding of over 600 words among 7000 pupils from 39 different schools. He found that some of the most popular words used by teachers of science in the classroom were simply not understood by the students. The result was a remarkable one and it triggered a series of similar investigations in the years to follow, right up to the present.

Farrel and Ventura (2010: 243) further emphasise that one of the most rigorous follow-up studies was the 1975–79 investigation carried out in Britain by James Cassels and Alex Johnstone. This large-scale investigation involved no less than 25,000 students on completion. In a preliminary report, based on a study of 4000 Scottish students and 2000 English students, Johnstone and Cassels (1978) described the observed effects of rephrasing a number of objective type (multiple choice) questions. They further state that in their article Ford and Peat (1998) assert that in essays and lectures Neils Bohr was constantly emphasizing the role played by language in science and in our understanding of nature. Scientific investigations, Bohr pointed out, are not exclusively formal, mathematical affairs for they also involve informal discussions in which key concepts are explored and understood.

In Bohr's words, "We are suspended in language in such a way that we cannot say what is up and what is down. In the case of quantum theory his views on language formed an essential component of the Copenhagen Interpretation ...the unambiguous interpretation of any measurement must be essentially framed in terms of the classical physical theories, and we may say that in this sense the language of Newton and Maxwell will remain the language of physicists for all time" (Farrel and Ventura, 2010: 243).

Therefore integrating science instruction with language teaching is a basic prerequisite for any successful science learning programme for second language learners. Practically speaking, this means that some of the classroom time allocated to science can be combined with that of language teaching. For foundation teachers; this is relatively simple as they are often responsible for most subject areas in their classrooms. More importantly, teachers can use language related teaching strategies and methods during science instruction.

Some educators would argue that science instructional time is already limited and that there is a vast amount of material in the curriculum. For them, integrating language and science is not an option because they see these two subjects as different and somehow unrelated. If they do integrate them, their efforts are often limited to the introduction of basic vocabulary terms

2.4 LANGUAGE TEACHING APPROACHES AND THE IMPORTANCE OF INCORPORATING LANGUAGE TEACHING AND SCIENCE

The approaches to teaching language are communicative, integrated, and process-oriented; text-based. According to the DBE (2011: 11) a communicative approach suggests that when learning a language a learner should have a great deal of exposure to the target language and many opportunities to practise or produce the language. Learners learn to read by doing a great deal of reading and learn to write by doing much writing.

The DBE (2011: 11) adds that the process approach is used when learners read and produce oral and written texts. The learners engage in different stages of the listening, speaking, reading, and writing processes. They must think of the audience and the purpose during these processes. This will enable them to communicate and express their thoughts in a natural way. For example, the teaching of writing does not focus on the product only but also focuses on the purpose and process of writing. During process writing, learners are taught how to generate ideas, to think about the purpose and audience, to write drafts, to edit their work, and to present a written product that communicates their thoughts.

“A text-based approach on the other hand teaches learners to become competent, confident and critical readers, writers, viewers, and designers of texts. It involves listening to, reading, viewing, and analysing texts to understand how they are produced and what their effects are. Through this critical interaction, learners develop the ability to evaluate texts. Authentic texts are the main source of content and context for the communicative, integrated learning and teaching of languages. The text-based approach also involves producing different kinds of texts for particular purposes and audiences. This approach is informed by an understanding of how texts are constructed” (DBE: 2011:11).

The text-based approach forms part of this study since it deals with science reading and analysing science text in order to understand specialised science terms. If learners understand the basic meaning and concepts in mechanics, this can help them to solve problems in science. In the previous section of the study, it was discovered that one obvious feature of the nature of scientific language is that it contains technical words that rarely occur in children’s everyday informal spoken interactions. This means that learners need to understand the terms well before they can apply knowledge thereof in real life situations.

The text-based approach has become very popular in China, as its promising results have been noted in the area of vocabulary acquisition. This approach implies that learning target words through reading texts, such as acquiring words’ meaning and their typical language environment from texts. In their article Johns and Davies (1983:1) refer that when using texts in learning and teaching vocabulary, a text can be described as a linguistic object, a vehicle for information and a stimulus for production When learners are exposed to new words in science, the words become stimulus to learning what the new words actually implies(Tingting, 2011:10).

“The text-based approach can be related to the comprehension approach; an umbrella term which refers to several methodologies of language learning that emphasises understanding of language rather than speaking. This is in contrast to the better known communicative approach where learning is thought to emerge through language production, i.e. the focus is on speech and writing” (Bennet 2007:1).

According to Bennet (2007:1) the comprehension approach is based on theories of linguistics, specifically Krashen's theories of second language acquisition, and is also inspired by research on second language acquisition in children, particularly the silent period phenomenon in which many young learners initially tend towards minimal speaking. In contrast, the communicative approach is largely a product of research in language education. In the context of this study, the comprehension approach gives learners an opportunity to understand the meaning of basic concepts in mechanics which can be later be translated into understanding on how to solve problems in science.

One of the teaching strategies often mentioned is providing learners with the opportunity to do what scientists do. This strategy aims to engage students in the same thinking processes and activities as practising scientists in which they might develop scientific concepts and ideas from their own experience (Swanepoel, 2010:71). However, this analogy of the student as novice scientist requires a clear image of the actions of scientists.

The image of a scientist as an individual surrounded by test tubes and equipment, ceaselessly exploring the material world, is a delusion (Osborne 2002; Scantlebury, Tal and Rahm 2007). Real scientists spend most of their time modelling or theorising, or evaluating competing theories (Halloun, 2007). Most of their work is not done in a laboratory, but in the writing and reading of papers, e-mail messages, and faxes that “fly between institutions” and “in the presentations and arguments engaged in at conferences” (Osborne, 2002).

This line of thought is supported by Norris and Phillips (*2009:*2) who claim that "constructing, interpreting, selecting and critiquing texts" are as much part of what scientists do as collecting, interpreting, and challenging data. Talking, listening, reading, and writing each have a role to play in science education.

If scientists spend most of their time reading, writing, and communicating verbally, then it is important for science educators to engage learners in reading and writing strategies in science classrooms. Incorporating Physical Sciences and English language teaching in the classroom will therefore be engaging learners in what real scientists do.

One of the activities of scientists include *reading* and learning from their reading. This is supported by Swanepoel (2010: 52) who contends that early research considered reading as a "passive, text-driven, meaning-taking process", but more recent research regard science reading as an "interactive-constructive" process (Hsu and Yang, 2007; Norris and Phillips, *sine anno*; Penney, Norris and Clark, 2003; Holliday et al., 1994). In order to ensure meaningful learning, teachers should mediate the interactions of students and text, providing meaningful purposes for reading, and strategies for meta-cognition (Thiede et al., 2003; Ulerick, *sine anno*).

According to Kim and Wai (2007:48) "one of the key factors in helping LEP students to achieve greater progress in learning science is the role played by science teachers in lowering the language barrier. With regards to this, Vine (1997) stresses that if content were to be made accessible to LEP students, teachers will need to move beyond leaving the language to take care of itself. As Kober (*sine anno*) note, research confirms the importance of integrating language development with science learning. Shaw (2002) emphasises the role of the content area teacher as a mediator. According to her, the science teacher must be cognisant of how to successfully mediate content knowledge and language instruction effectively to LEP students. This is in line with Vygotsky's notion of the zone of proximal development, and Bruner's concept of scaffolding whereby the teachers need to adjust their instruction to support the learners' existing capabilities so that they are able to perform beyond their current levels of functioning".

The above utterances indicate that incorporating English language teaching in science classrooms will give learners an opportunity to explore language structures while using science text and thereby actively construct meaning from what they are reading. Reading science text is a skill that must be taught in the science classroom as compared to reading a novel or a current affairs newspaper.

Kim and Wai (2007:48) also agree that by giving English language learners more opportunities for using the language of science, science content is made more accessible to them. They propose that teachers must identify the linguistic structures or discourse patterns associated with a particular topic and then incorporate appropriate language learning activities into their science lessons.

As already mentioned that learning the language of science is like learning a new language; scientists use scientific words for common words that we already know. For example, the word “magnitude” is used instead of “size” or “delta” instead of “change in”. This type of specialised vocabulary is what makes science distinct from other disciplines.

Krupp (2009:2) conducted a study which investigated the impact of teaching vocabulary and comprehension strategies in Grade 7 classrooms. The results showed that such strategies can improve academic success. However, in South Africa few studies have been conducted which incorporate Physical Science and English language teaching, especially to learners for whom English is a first additional language.

Muzah (2011:1) in his exploratory study which investigated school-related factors responsible for high matriculation failure rates in Physical Sciences in Alexander township public schools in South Africa discovered that one of the contributing factors was proficiency in the language of teaching and assessment which is mainly English in many township schools.

For this reason, language issues cannot be overlooked in Physical Science which is one of the most failed subjects in South Africa especially in Grade 12.

Setati (2011:26) states that language makes it possible for us to understand and make sense of the world of Science by providing a cognitive framework of concepts. It is through the use of such a framework consisting of words and meanings that we interpret the concepts and exchange information about them with other people. Our entire knowledge and experience of the Science concepts is mediated by language. This means that academic achievement in science depends on a person's ability to use language. Communication in science relies heavily on context reduced, cognitively demanding language, which has been identified as being particularly difficult for second language learners to acquire (Cummins, 2000).

Setati (2011: 28) also asserts that the importance of language in learning and teaching science cannot be under-estimated. It is important for learners in developing their scientific knowledge, and for educators in understanding their learners' learning processes. However, research has shown that the ways in which educators and learners use language in the classroom are complex and that the effects, though considerable, are often highly subtle and not self-evident.

It is therefore important to develop what happens with language, why it happens, and how it happens, since language is a tool used for expressing information and ideas. This can be done by designing programmes that incorporate appropriate language pedagogy in science classroom.

2.5 READING AND COMPREHENSION SKILLS NECESSARY FOR SCIENCE LEARNING

Reading is a powerful learning tool in the science classroom since learners need to investigate theories and principles in science. For instance, a learner may be asked to state Newton's First Law in words and later be asked to apply this law in a problem solving setting. This requires learners to be able to read extensively in order to understand this concept well.

According to Madileng (2007: 12) reading skills are extremely important for academic development and therefore a skilful reader, who possesses both receptive and productive aspects of language use, can acquire a higher level of comprehension and higher order skills which are very important for academic success. A poor reader cannot be a good writer as both skills complement each other. This means that poor readers will not cope with the demands of higher vocabulary skills that are needed to learn new science concepts.

As an experienced science teacher, I have discovered that learners who succeed in science are learners who have the skills of working independently and this automatically means that they are skilful readers.

Coleman (2003: 2) conducted a study to determine whether extensive reading can improve learners' comprehension skills, increase their academic achievement, and promote higher achievement in general academic subjects. In this study, one hundred and twenty-one learners comprising of extensive-readers, less-extensive readers, and non-extensive readers were identified and studied. The results indicated that extensive reading not only leads to improved achievement in comprehension, but also to improvement in general academic performance in all subjects across the curriculum.

The above indicates that reading cannot be underestimated in the academic fraternity, especially in the discipline of science which has its own language. Consequently there is a move to incorporate reading in science classrooms which can help to improve academic achievement in Physical Sciences. Science teachers must encourage learners to read; especially reading with the purpose of understanding Physical Sciences concepts.

Aebersold and Field (1997) in Willemse (2005:40) define reading as what happens when people look at text and assign meaning to the written symbols in the text; it is the interaction between the text and the reader that constitutes actual reading. According to Granville (2001) the two most important processes involved in reading are decoding and comprehension, with the former referring to the translation of written signs into language, and the latter to the absorption and understanding process whereby the aims of reading are met by giving meaning to the text.

Reading in the context of science also involves decoding and comprehending science concepts. For instance a learner may translate the concept of “acceleration” well but have no understanding of it; this is done in the decoding stage. Then once the concept is understood, comprehension takes place.

It is argued that in many reading tests, distinction is generally made between the decoding and comprehension abilities of readers. According to McCormick (1995) in Willemse (2005:40-41) readers can be divided into the following categories:

- The independent level: readers in this group are believed to be highly skilled and can read with 98% decoding accuracy and at least 90% comprehension. These readers should be able to access information from text without any problem and simultaneously be able to learn from it.
- The instructional level: readers in this group are believed not to have major reading problems as they read at 95% decoding accuracy and at least 75% comprehension. It is generally assumed that readers in this category can benefit from reading instruction.

- The borderline: readers in this category attain between 90-94% decoding accuracy and 55-74% accuracy in comprehension. They are borderline cases that can benefit from intensive reading instruction.

- The frustration level: readers in this category are believed to have major reading problems and read with less than 90% decoding accuracy and 50% or less comprehension. To overcome their difficulties in comprehension, they need intensive reading instruction.

This suggested that in the discipline of science, even independent readers may experience problems because science is a subject with its own specialised vocabulary. For the independent level reader, at least learning science will be easier since there is high level of language proficiency level. However the frustration level reader has problems both in understanding the English language and understanding the language of science.

The fact is that many secondary school learners in South African may be categorised in the frustration level category of reading. This is because English is a first language to less than 10% of the population in South Africa. Although they are able to express themselves well in English, it does not mean that they are competent in using the language for academic purposes. Most of the learners in South Africa who learn Physical Sciences through a second language can benefit from intensive language instruction. This can be done by incorporating some of the language strategies in science lessons.

Different models of text comprehension can be used to explain how people interact with text (Stahl, Jacobson, Davis and Davis, 2006; Walsh, 2006; Best, Rowe, Ozuru and McNamara, 2005; Norris and Phillips, *sine anno*, Boscolo and Mason, 2003; Otero and Campanario, 1999). The *comprehension integration* (CI) model of text comprehension was developed by Kintsch (Kintsch and Kintsch, 2005; Best et al., 2005; Boscolo and Mason, 2003; Broer, Aarnoutse, Kieviet and Leeuwe, 2002; Iding, 2000; McNamara, Kintsch, Songer and Kintsch, 1996; Swanepoel, 2010: 52).

Three levels are defined in the comprehension process. The first level is the *decoding process*. Learners must convert the printed words into meaningful sentences in their minds. If the words are too difficult (semantically difficult) or the reader has trouble putting the words together to form the sentence (syntactically difficult) the first level of processing will be unsuccessful (Fry, 2002, in Swanepoel, 2010:52). Most of the words in science are not easy to decode since they are specialised words which do not occur in learners' everyday lives. The first process in the science class will therefore be to engage learners in understanding the meaning of these words which will require language teaching strategies.

Once learners have understood the basic meaning of words, the second level of text processing is called the *textbase*. The learner must integrate different sentences to create a coherent text-level presentation (Best et al., 2005; McNamara et al., 1996). The text does not normally provide all the information relevant to the subject of the text (Boscolo and Mason, 2003), but the reader has to infer connections and relationships not explicitly stated in the text (Walsh, 2006; Best et al., 2005; McNamara et al., 1996) Research has shown that coherent texts can facilitate this level of processing successfully. Coherent texts provide, where possible, the necessary connections and therefore, require little interference activity from reader (Swanepoel, 2010:54). This is what will actually happens in science; learners may for example know that "acceleration is the rate of change of velocity", but not understand the meaning of this concept.

The third level of the comprehension integration model entails processing the textbase under the influence of the prior knowledge of the reader to construct a *situation model* (Kintsch and Kintsch, 2005). This is a mental model of the situation described by the text. Text content and organisation can support learning and it is even possible for the text to moderate a lack of sufficient or accurate prior knowledge (Kendeou and Van den Broek, 2005; Mikki a-Erdmann, 2002). While it is obvious that textbooks must not be too difficult for learners to read, McNamara et al. (1996) warn against texts that are easy to understand. They contend that textbooks that are too easy could reduce the amount of active processing.

This may also increase direct recall of the text which leads to less effective learning (Boscolo and Mason, 2003; McNamara et al., 1996), since information that is actively generated is better remembered and better put to use in novel situations (Clark and Salomon, 2001). When considering the comprehension of texts with illustrations, both Kintsch's CI model of text comprehension and Paivio's *dual coding theory* can provide a theoretical backdrop (Vekiri, 2002; Iding, 2000). Dual coding theory proposes that two distinct and independent but interconnected cognitive systems exist for the processing of verbal and non-verbal information. This theory can explain why Mayer (2003) found that students learn more deeply from words and pictures than from words alone (under the right conditions). It is obvious that the illustrations in textbooks can contribute to the learning process in science education and therefore influence the quality of the textbook. The visual design or layout of a textbook can give salience to some elements in the text; the elements can be marked as more important and more worthy of attention than others. This is attained through relative size, sharpness of focus, relative positioning, tonal contract, and colour contrast (Hsu and Yang, 2007).

In short, text comprehension is important in reading. It is possible to find learners who spend most of their time reading, but still perform poorly in tests. The reason may be that the reading strategies they use are not appropriate and do not help them to understand the concepts. Incorporating language teaching in science classes accompanied by activities to promote active reading rather than passive reading would be ideal.

2.6 OVERVIEW OF PHYSICAL SCIENCES CURRICULUM ACCORDING TO CAPS

The South African Department of Basic Education (2011:8) states that:

Physical Sciences investigate physical and chemical phenomena. This is done through scientific inquiry, application of scientific models, theories and laws in order to explain and predict events in the physical environment. This subject also deals with society's need to understand how the physical environment works in order to benefit from it and responsibly care for it.

All scientific and technological knowledge, including Indigenous Knowledge Systems (IKS), is used to address challenges facing society. Indigenous knowledge is knowledge that communities have held, used or are still using; this knowledge has been passed on through generations and has been a source of many innovations and developments including scientific developments. Some concepts found in Indigenous Knowledge Systems lend themselves to explanation using the scientific method while other concepts do not; this is still knowledge however. According to the statements alluded above it is evident that learners needs high academic language skills to study physical sciences since they are required to investigate physical and chemical phenomena through scientific inquiry, application of scientific models, theories and laws which must be read and comprehended for understanding in order to explain and predicts events in the physical environment.

To do science a learner needs to be able to interpret scientific theories and laws which must be investigated and applied in the later stage. For example, a learner needs to understand the concept of gravitational acceleration before he or she can investigate and find its value. Science and language cannot be separated from each other as learners are also required to write scientific reports about their findings which require writing skills.

DBE further suggests that:

> …the purpose of Physical Sciences is to make learners aware of their environment and to equip them with investigating skills relating to physical and chemical phenomena, for example, lightning and solubility. Examples of some of the skills that are relevant for the study of Physical Sciences are: classifying, communicating, measuring, designing, investigating, drawing and evaluating conclusions, formulating models, hypothesising, identifying and controlling variables, inferring, observing, comparing, interpreting, predicting, problem-solving, and mastering reflective skills.

Some of the skills mentioned above need high levels of language proficiency. For learners with language problems, especially second language learners, this can prove to be very difficult. For example, learners are not able to formulate hypotheses if they have problems with English writing skills.

Physical Sciences deal a lot with problem solving. This is supported by DBE (2012: 11) that Physical Sciences promotes knowledge and skills in scientific inquiry and problem solving; the construction and application of scientific and technological knowledge; an understanding of the nature of science and its relationships to technology, society and the environment. Physical Sciences prepare learners for future learning, specialist learning, employment, citizenship, holistic development, socio-economic development, and environmental management. Learners choosing Physical Sciences as a subject in Grades 10-12, including those with barriers to learning, can have improved access to: academic courses in Higher Education; professional career paths related to applied science courses and vocational career paths. Physical Sciences play an increasingly important role in the lives of all South Africans owing to their influence on scientific and technological development, which are necessary for the country's economic growth and the social wellbeing of its people.

As indicated above, that Physical Sciences prepare learners for future learning, specialist learning, and employment which can only happen if they are at the independent level category of readers who are highly skilled and can read with 98% decoding accuracy and at least 90% comprehension. Readers in this stage are said to be able to access information from text without any problems and simultaneously be able to learn from it. This level of proficiency is necessary if learners are to take physical sciences as a major subject.

In order to learn science, a learner needs to understand word problems which involve both basic reading skills and science vocabulary skills. Vocabulary knowledge includes words like 'velocity', 'displacement', and 'acceleration'. On the other hand basic academic language skills include terms like 'induce', 'emit', and 'magnitude' which are necessary for the learning of science. Below is an extract of a physical sciences text from a grade 10:

An object accelerates when a change in its velocity occurs, e.g. when the speedometer of a motor car is moving clock wise or anticlockwise an object accelerates if:

- *The magnitude of its velocity changes (if velocity increases or decreases)*
- *The direction of movement changes.*

In the text, the words 'accelerates', and 'velocity', are technical words. Words like 'object', 'occur', 'clockwise', 'anticlockwise' and 'magnitude' are academic words which are necessary for science learning.

Poor scholastic performers are also poor readers. This is confirmed by Pretorius (1996:450) by describing readers with good comprehension skills as "generative"; constantly add new knowledge to their schemata as well as refining and adapting their reading strategies. On the other hand poor readers are "inert" and rigid. They cannot move from decoding abilities to comprehending skills.

According to Muzah (2011: 84) one of the factors that contribute to high failure rates in mathematics and science is the language of teaching and learning (LOTL). He adds that the literature reveals South African learners whose main language is an African language often have different levels of competence in English which does not match the first language of the majority black learners. Muzah (2011: 86) further indicates that studies reveal that learners in South African township and rural schools lack the required cognitive academic language proficiency to execute higher order cognitive operations through a second language such as English . CALP is important for one to succeed in science. English proficiency does not guarantee that one will succeed in learning science since science is a subject with its own academic language. For learners to be able to read academic material they need to practice how to read in the science classroom. Fortunately, the introduction of CAPS has emphasised the importance of textbooks in the curriculum. If learners have textbooks, it will be easier for science educators to expose learners to reading. The next section discusses more about BICS/CALP distinction.

2.7 CONCEPTUAL FRAME WORK

This section discusses the theoretical framework of the study and the following educational theories: behavioural theories of learning and how they are related to science and language learning, cognitive learning theories, and constructivist theories. Lastly, theories of second language learning are also discussed.

2.7.1 BEHAVIOURAL LEARNING AND READING IN SCIENCE CLASSROOM

Learning according to Woolfolk (2007:206) is a process through which experience causes permanent changes in knowledge or behaviour. To qualify as learning, a change must be brought about by experience; and experience can be brought about by reading science texts. This permanent change in knowledge is emphasised by behavioural learning theories of learning which assume that learning focuses on external events as the cause of changes in observable behaviour. The implications of the above is that if learning is brought about by experience, incorporating language and science can bring about permanent changes in behaviour. If learners are exposed to reading strategies in science classrooms, they will benefit from it.

Woofolk (2007: 208): further suggests that one of the theories of behavioural view of learning was classical conditioning. Classical conditioning was discovered in the 1920's by Ivan Pavlov, a Russian Psychologist trying to determine how long it took a dog to secrete digestive juices after it had been fed. At first the dog salivated as it was being fed and later salivated when they saw the food. Then dogs started to salivate once they heard the scientists walking. Then later Pavlov discovered that the dog could be conditioned to salivate after hearing the sound of the turning fork.

The above indicates that science teachers can condition learners by introducing reading strategies in science lessons. For every lesson topic, educators can allow learners an opportunity to read their textbook for about twenty minutes before introducing the topic. Language comprehension tasks that will encourage learners to read the task can be designed for every lesson topic. By doing so, learners will be conditioned that for every new subtopic there is a task which requires them to read before the topic is introduced. The reading task will be the conditioned stimulus while the response to the task will be conditioned response.

Trowbridge et al (2004: 25) emphasise that in the classroom situation, the behaviourist approach emphasises cause and effect (stimulus-responses) which are measurable. In other words it stresses that learning results in desirable changes in a learner's behaviour if the teaching methods and learning materials chosen by the science educator have great impact on the learner.

To be more precise, science educators should first ask themselves which kind of behaviours they expect in their learners from a science learning experience and then determine the reinforcers and stimuli such as the environment, subject content, teaching methods, apparatus, motivation, rewards, and experiments and how these reinforcers can be best used to contribute in the best way to the behavioural changes which the educator has in mind. In the case of the study, the kind of behaviour that is expected from learners is to be proficient in reading in the context of science and this is done by engaging learners in reading in science classroom.

2.7.2 THE COGNITIVE VIEW OF LEARNING AND INCORPORATING SCIENCE AND LANGUAGE

According to Woolfolk (2007:248) the cognitive view of learning is a general approach that views learning as the active mental process of acquiring, remembering, and using knowledge. She adds that according to the cognitive view, knowledge is learned, and changes in knowledge make changes in behaviour possible.

The implication of the above is that if learning is an active learning process, then when learners read a science text, they are actively involved in the process of finding meaning in what they are reading. For the purpose of this study, attention will paid on metacognition as an important aspect of cognitive development.

Metacognition is grounded in the cognitive theories of Jean Piaget, a Swiss psychologist and developmental scholar. In Piaget theory of cognitive development there are phases in children's cognitive development. Wai (2009:7) lists the four phases identified by Piaget. The sensorimotor stage lasts from birth to 2 years and is the first cognitive development phase. During this phase, infants understand the world by exploration. The second phase of is called the preoperational stage from 2 to 7 years old. In this period children use some tools such as gestures and words instead of motor actions, to think about objects and events.

Woolfolk (2007: 267) defines metacognition as knowledge about our own thinking. She asserts that this knowledge is higher order cognition and is used to monitor and regulate cognitive process such as reasoning, comprehension, problem solving, and learning. By reading science texts, learner is engaged in metacognitive process since they have to comprehend what is learned. Woolfolk further emphasises that metacognition involves three types of knowledge, namely declarative knowledge, procedural knowledge, and conditional knowledge. Declarative knowledge is knowledge about one's self, the factors that influence learning and memory, and the skills, strategies, and resources needed to perform a task. This implies that a learner at the independent reading level might have knowledge on how best she can learn and what the factors are that may hinder his/her learning. Procedural knowledge knowing how to use the strategies discussed in declarative knowledge. Conditional knowledge is knowing when and why to apply certain strategies and procedures. It stands to reason that when learners apply these strategies they will be able to manage their own learning.

By teaching them to read in science classrooms, teachers will be developing learners' metacognitive skills. This is supported by Wai (2009:6) that "teaching a variety of metacognitive strategies in reading, including setting goals beforehand, monitoring to check for understanding, re-reading to confirm the meaning of unclear parts, and evaluating performance after reading, are considered effective ways for learners to develop reading comprehension". If these strategies are applied in science classrooms learners can develop the requisite higher order thinking for science learning.

One of the stages in Piaget's theory of development is the stage from 7 to 11 years called concrete operational phase when children think logically about concrete objects and events, the last period from 11 years onwards is identified as the formal operational stage. Children in this phase develop abstract reasoning with language. The implications of the above are that as science teachers we can relate Piaget's formal operational stage and metacognition strategies to reading strategies in the science classroom. This can be done by following the three metacognitive strategies described by Wai (2009:41-42) which include planning, monitoring, and evaluating. The planning phase usually occurs before reading the text. The teacher can do this when introducing a new topic allowing learners to examine the title of the topic, subtopic, and pictures before reading the text. A preview of the topic gives readers an overview of the topic and makes it easier to grasp.

Secondly, the monitoring strategy usually occurs during reading and includes self-questioning, reflecting on whether what is read is understood, and inferring from the main idea of the topic. Lastly, the evaluation stage which is employed after reading, involves allowing learners to think about how they can use the information they just read in other situations. In the science classroom, it is what we do every day in problem solving and therefore this will not be a problem. These strategies can help less skilled readers to develop academic reading skills which are not taught in the normal English classroom. The main idea is to develop the vocabulary they need in learning science.

2.7.3 CONSTRUCTIVIST THEORY AND INCORPORATING LANGUAGE AND SCIENCE

The core of constructivism is the belief that learning is an active process in which learners construct new ideas and knowledge based upon their current and past experiences. The learner selects and transforms information, constructs hypotheses, and makes decisions, relying on a cognitive structure to do so (Brunner, 1986). This view replaces the more traditional view that knowing a subject is a pure entity unaffected by biological, psychological, and sociological contingencies (Setati, 2011: 47).

On the other hand Osborne and Wittrock (2003:103) describe constructivist theory adapted for science learning as the ability to comprehend what learners are taught verbally, or what they read, or what they find out by watching a demonstration or doing an experiment. The learners must invent a model or explanation that organises the information selected from the experience in a way that makes sense to them, that fits their logic or real world experiences, or both. Thus, learners learn by thinking about and trying to make sense of what they see, feel, and hear all around them. Furthermore, in trying to make sense, the learner utilises all his/her existing knowledge, namely current experience, past experience, textbook knowledge, and learning from society (elders, the media, cultural legends, etc) (Setati, 2011:48) .

Constructivist perspectives are grounded in the research of Piaget, Vygotsky, and the Gestalt psychologists Bartlett and Bruner, as well as the philosophy of John Dewey. According to Woolfolk (2007:344) there is not only one constructivist theory of learning, but “most constructivists share two main ideas: that learners are active in constructing their own knowledge and that social interaction is important to knowledge construction.” The focus of this research is on knowledge construction through the reading of texts. Social interaction takes place between the text and the reader as the reader tries to comprehend what is read.

Day and Brumfit (1982) define reading as “the construction of meaning from printed or written messages” (Madileng, 2007). Coleman (2003:65) further emphasises that when learners read, they are able to relate what they see on paper to what is already in their minds. The learner in other words, tries to predict lines of thought, interrogates the author on his position, and evaluates the work for its usefulness and importance in his own life (Setati: 2011:49).

Therefore the learner cannot apply Newton’s first law unless he/she has read and understood the law well. Although the teacher may teach the learner about this law, the learner will still need to read about it when preparing for exams and tests. Engaging learners in reading strategies is therefore important in science learning.

Windschitl, (2002) the constructivist view embraces psychological and social constructions. Psychological constructivism focuses on how individuals use information, resources, and even help from others to build and improve their own mental models and problem-solving strategies. In contrast, social constructivism sees learning as increasing our abilities to participate with others in activities that are meaningful in the common culture (Woolfolk, 2007: 345). The focus of the study is on psychological constructivism as the study deals with the interaction between the learner and science text.

According to Yore et al (*sine anno*:3-4) reading is not simply a uni-dimensional bottom-up or top-down process involving printed symbols. Rather, reading is an interactive-constructive process that involves making meaning by negotiating understanding between the text and the reader's concurrent experiences and memories of a topic, and recognises the importance of prior knowledge, strategies, metacognition (awareness and executive control of meaning making), and the socio-cultural context. In other words when learners read science texts, they construct meaning according to their own understanding and prior knowledge.

Different learners for example, may interpret Newton's first law differently depending on their own circumstances because reading is an active not a passive learning process. By reading science text, there is a social interaction between the learner and the text, which means that the learner will be engaged in constructivism.

Science text, unlike familiar content and predictable story lines in children's literature, contains unfamiliar content and text structures, heavy conceptual demands, and unique vocabulary. The purpose of scientific text is to assist uninformed and misinformed readers to construct meaning about specific science ideas using an expository approach, words (concept labels) with specific meanings, complex and interconnected sentences, and specific text structures (description, collection, compare/contrast, problem/solution, causation) (Yore et al, *sine anno:* 3-4). Incorporating reading strategies will therefore help learners to construct scientific knowledge rather than merely decoding and comprehending specialised words.

2.7.4 THEORIES OF SECOND LANGUAGE LEARNING

There are several theories of second language learning which include the input hypothesis, the interaction hypothesis, the output hypothesis, and Vygotsky's theories on language and thinking. For the purpose of this study, the focus is on the input hypothesis and Vygotsky's theories.

The input hypothesis states that in order for language acquisition to take place, the acquirer must receive comprehensible input through reading or hearing language structures that slightly exceed their current ability (Krashen, 1985:143; Brown, 2000:278; Setati, 2011:38). They assert that if the learner is exposed to sufficient input and the input is understood, the necessary grammar is automatically provided. What is criticised in this theory is the claim that 'comprehensible input' is sufficient.

The implication in the above statements is that learners must be exposed to different types of language structures in order to learn a language. Consequently, encouraging learners to read different types of science text in class will help them comprehend the important words required for science learning.

Vygotsky (1962) as quoted by Setati (2011:42) viewed language as having two main functions. Firstly, as a communicative and cultural tool used for acquiring, developing, and sharing knowledge and culture, this enables human social life to continue. Secondly, quite early in childhood, language is used as a psychological tool for organising individual thoughts; for reasoning, planning, and reviewing their actions. Mercer (2001) asserts that “Vygotsky also believed that in early childhood, language fuses with thinking and shapes the rest of the individual’s mental development).

For the purpose of this study language is viewed as a communicative and cultural tool for acquiring and developing science knowledge. Learners acquire knowledge through reading scientific texts with the hope of increasing their science vocabulary to enable comprehension of important information in their textbooks.

The theoretical framework of this study is based on the work of one Linguist, researcher Jim Cummins.

> “Cummins has focused on language acquisition in bilingual children. His research began with a study conducted in 1979 that was based on the earlier work of Swedish scientist Skuthabb-Kangas Toukomaa (1976). Cummins and his team followed the progress of recent Swedish immigrants as they acquired a second language, English. They noticed two significant patterns in the language acquisition process. First, proficiency in the first language (L1) helped to develop the second language (L2). Cummins used the term developmental interdependence to describe this interaction. The second observation was that older Swedish children seemed to do better at acquiring L2 proficiency. This observation led Cummins to believe that there was a difference between surface fluency and cognitively or academically related proficiency (1983). In time, Cummins began to describe surface fluency as basic interpersonal conversation skills (BICS), while higher

> level proficiency was called cognitive academic language proficiency (CALP). Thus, the BICS/CALP distinction was born to describe the different stages of second language acquisition" (Lillywhite, 2011:6-7).

The above implications suggest that even if learners are able to communicate fluently in English language, especially in South Africa where majority learners learn through second language that does not mean that they are able to use English language to learn cognitively demanding subjects like Physical Sciences. In order to cope they will need to have CALP skills.

Street and Hornberger (2008: 2-3) further suggests that the initial theoretical intent of BICS/CALP distinction was to qualify Oller's (1979) claim that all individual differences in language proficiency could be accounted for by just one underlying factor, which he termed global language proficiency. Oller synthesized a considerable amount of data showing strong correlations between performance on cloze tests of reading, standardized reading test, and measures of oral verbal ability. Cummins (1979) however, argued that it is problematic to incorporate all aspects of language use or performance into just one dimensions of general or global language proficiency

Street and Hornberger (2008:3) further site an example that if we take two monolingual English-speaking sibling, a 12 year old and a 6 year old, there are enormous differences in these children's ability to read and write English and in-depth and breadth of their vocabulary knowledge, but minimal differences in their phonology of basic fluency. The 6 year old can understand virtually everything that is likely to be said to her in everyday social contexts and she can use language to very effectively this context just as the 12 year old can. In other words, some aspects of the children's first language development reach a plateau relatively early whereas other aspects (vocabulary knowledge) continue to develop throughout our lifetimes. Thus these very different aspects of proficiency cannot be considered to reflect just one unitary proficiency dimensions.

This is supported by Cummins (2000: 67) who assets that CALP or academic language proficiency develops through social interactions from birth but becomes differentiated from BICS after the early stages of schooling to reflect primarily the language that children acquire in school and which they need to use effectively if they are to progress successfully through the grades. The notion of CALP is specific to social context of schooling, hence the term "academic. Academic language proficiency can thus be defined as "the extent to which an individual has access to and command of the oral language and written academic registers of schooling".

The implications of the above are that learners need CALP skills if they are to disseminate science knowledge successfully. Basic interpersonal communication skills allow learners to converse fluently in demanding natural situations, while cognitive academic language proficiency enables learners to understand academic concepts and perform higher cognitive operations required of a person at a school or institution of higher learning. Physical sciences as a subject require learners to have higher cognitive and academic language skills since it is a subject with its own language.

Cummins (1996) as quoted by Woolfolk (2007:185) further argues that one should be careful not to judge learner proficiency in a second language on their proficiency in basic interpersonal communication skills, because learners are sometimes able to express themselves well in English in natural settings, but still perform very poorly academically. Deficiency in cognitive abilities could be blamed for poor academic performance when learners have not yet developed adequate levels of cognitive academic language proficiency to cope with academic work

The important point here is that incorporating cognitive academic language skills into Physical Science teaching helps learners to cope with their academic studies. In normal English classroom settings, learners are taught reading comprehension, but not in the context of Physical Sciences. Therefore in the science classroom learners need to learn reading and comprehension skills in the context of science.

2.8 SUMMARY

This chapter argued that language must be taken into consideration in science teaching and explored the importance of language by firstly describing what language is, and later discussed importance of incorporating science and language teaching. Theories that support the integration of language and science were also discussed. It was concluded that language cannot be separated from science and that language teaching must be the core business of every science teacher. The next chapter presents the research methodologies used in the study.

CHAPTER 3
RESEARCH DESIGN AND METHODS

3.1 INTRODUCTION

This chapter discusses the research methodologies employed to explore the effects of incorporating English language teaching in Physical Science lessons. Firstly the research design and the data collection methods are discussed. Secondly the sampling methods and development of the instruments are discussed. This is followed by a description of the implementation of the pilot study including measures taken to ensure validity and reliability. Lastly the chapter discusses ethical considerations and the data analysis methods.

3.2 RESEARCH METHODOLOGIES AND DESIGN

Mouton (2005:56) asserts that research methodology focuses on the process and the kind of tools and procedures to be used by the researcher. The point of departure is on specific tasks (data collection or sampling) at hand. Methodology also focuses on the individual (not linear) steps in the research process and the most "objective" (unbiased) procedures to be employed.

For the purpose of triangulation, both qualitative and quantitative methodologies were employed. McMillan and Schumacher (2010:25-26) state that triangulation is used to the extent that the results from each method converge and indicate the same results. Furthermore, it is emphasised that triangulation is the strategy of using different kinds of data-collection instruments such as tests, direct observation, interviews, and content analysis, to explore a single problem or issue (Borg and Gall, 1983, in McMillan and Schumacher, 2010: 25-26). Triangulation in this study was informed by the fact that the researcher wanted to explore all aspects related to incorporating language teaching and science content teaching.

3.2.1 QUALITATIVE RESEARCH DESIGN

Qualitative research is regarded as an unstructured approach to inquiry that is flexible with regards to the objectives, design, sample, and questions asked in order to explore the nature of a problem, issue, or phenomenon (Kumar, 2002, Van Staden, 2010:51). In addition the qualitative researcher uses a variety of research methods and empirical materials such as interviews and texts written by individuals to get a better understanding of the situation or the problem at hand (Denzin & Lincoln, 2000, Van Staden, 2010:51).

With reference to this study, the qualitative part of this study was informed by the fact that the researcher wanted to explore the effects of incorporating English language teaching in science classroom in depth. This could only happen if the researcher utilised qualitative methods in order to better understand the situation. One of the aims of this study is to identify teaching methods that are used in language teaching which can be incorporated in science classroom. Such methods can be observed in class and this can only happen if the researcher is using qualitative methodology.

3.2.2 QUANTITATIVE RESEARCH DESIGN

The quantitative part of this study followed the pre- and post-test methods. In the past behavioural Sciences conformed to the scientific epistemology which advocated that any phenomenon could be described and reduced to its statistical or numerical elements, and collated and attributed to causal powers (Setati, 2011:100). Leedy and Ormrod (2005:94) explain that quantitative research is used to answer questions about relationships amongst measured variables, and about testing hypotheses with the purpose of explaining, predicting, and controlling phenomena.

A non-equivalent group pre-test-post-test control or comparison group design was employed in the study. According to McMillan and Schumacher (2010:278) in these control designs the researcher uses intact, already established groups of subjects, gives the pre-test, administers the intervention condition to one group, and gives the post-test.

With reference to the research aims of this study, one of the aims of the study is to investigate whether incorporating English language teaching in science education can improve learner academic performance. Therefore the quantitative part of this study was based on that fact and that is why the pre-test/post-test method was utilised.

3.2.3 CASE STUDY

Qualitative and quantitative approaches are applied in case study research designs. According to De Vos (2005:389) a research design is a logical strategy for gathering evidence about desired knowledge. McMillan and Schumacher (2010:22) further indicate that research design summarises the procedures for conducting a study, including when, from whom, and under what conditions the data will be obtained. In other words, a research design indicates the general plan: how the research is set up, what happens to the subjects, what methods of data collection are used, and how the data generated will be analysed and interpreted.

As indicated above a research design summarises the procedures for conducting a study. McMillan and Schumacher (2010:344) emphasise that a case study is an in-depth analysis of a single entity. In this study a single school was used instead of many schools because the nature of the study required an in-depth investigation.

Johansson (2003: 2) confirms that a case study is expected to capture the complexity of a single case; this has developed within the social sciences. Such methodology is applied not only in the social sciences, such as psychology, sociology, anthropology, and economics, but also in practice-oriented fields such as environmental studies, social work, education, and business studies.

Johansson (2003: 2) further adds that triangulation provides an important way of ensuring the validity of case study research. Normally, data collection methods are triangulated (many methods are combined), but in addition to this, data sources, theory, or investigators might also be triangulated. The above statement explains why it was necessary to use a mixed-methods approach in the study.

3.3 SAMPLING

Mkandawire (2009:48) defines sampling as a process in research whereby a small group that forms part of a larger group is identified. The small group is called a sample from which Information is obtained. The study was conducted in one school in the Kwamhlanga area in Mpumalanga Province. The school was chosen using convenience sampling because the researcher works at the school.

Convenience sampling is a type of non-probability sampling method of selecting subjects who are accessible or available (McMillan and Schumacher (2010: 486). That is, readily available and convenient. In most cases the researcher chooses a sample based on who they think would be appropriate for the study. The nature of this study required that the researcher regularly works and teaches the learners to identify the effects and patterns that emerge from incorporating Physical Sciences and language teaching.

Kwamhlanga area is formally known as KwaNdebele area. This means that majority of the people in the area speak IsiNdebele as a home language. The school is a post level 5 school and for this reason it is one of the biggest schools in this area with about 1400 learners and 48 educators. The language of learning and teaching in the school is mainly English. The school is offering isiNdebele and Sepedi as home languages. The lowest grade at the school is grade 8 and the highest grade is grade 12.

Most of the learners come from poor family backgrounds and for lunch they depend on the school's feeding scheme. The KwaMhlanga area is economically poor since there are no factories or towns near the area. The learners' academic performance is affected by the contextual factors mentioned above.

It is difficult for some of the learners to even do their homework as they often share a room with other siblings, and sometimes the whole family live in a one- bedroom shack where they have to wait for other children to sleep before they can study. This situation is exacerbated by the fact that they are not proficient in English which is the language of learning and teaching. In order to survive academically interventions must be made to lower the language barrier.

Physical Sciences learners in Grade 10 participated in the study. In grade 10, there are two classes of learners that are majoring in mathematics and Physical Sciences. Initially 75 learners participated in the study but for reporting purposes the results of 68 were used. This is because some of these learners were absent when the pre-test and the post-test were written. Therefore their results could not be used when reporting as they only have marks for one test. The learners are English second language learners which mean that their proficiency in English is not satisfactory. Since the language of teaching and learning is mainly English it means that they learn in a language that is different from their home language.

3.4 DESCRIPTION ON THE DEVELOPMENT OF INSTRUMENTS

The instruments employed in the study included the workbook, an interview schedule, and pre- and post-tests. The workbook was designed to correlate with the content prescribed in Curriculum and Assessment Policy Statement and at the same time to enhance the learners' comprehension and vocabulary skills in Physical Sciences. In other words, it had to integrate Physical Sciences and language teaching. The pre-test was identical to the post-test and the main aim of the pre-test was to set a bench mark for comparison after the introduction of variables. The test and workbook was based on topics in mechanics for the Grade 10 syllabus and excluded the topics of equations of motion, and work and energy. Below is a description of how the workbook and the pre- and post test were developed.

3.4.1 WORKBOOK

In the context of the study a workbook is referred to as an exercise or textbook used for study, especially a textbook with spaces for answers. It allows learners to read the questions and write their response in the same book. This implies that it is interactive and therefore encourages reading and writing skills.

The design of the workbook was based the topics prescribed in the CAPS document for Physical sciences. The CAPS document (DBE, 2011: 40-42) for Physical sciences in Grade 10 indicates that the topic of mechanics in third term must cover the following sub-topics:

- Vectors and scalars
- Motion in one dimension which include reference frame
- Position, displacement, and distance
- Average speed, average velocity
- Acceleration and instantaneous speed and velocity
- Graphs of motion

- Equations of motion

The study was based on all the topics above except equations of motions. In addition, it was compiled by the researcher using the physics textbook for Grade 10 by A Olivier (*sine anno*) and the Oxford Successful Physical Sciences textbook by Broster et al (2011) used by the learners at school. The workbook was designed to incorporate language teaching and Physical Sciences content teaching.

The contents of the workbook included notes for the topic, Physical Sciences activities, and English activities which incorporated language lessons and Physical Sciences. There were five units or sub-topics from the knowledge area of mechanics, namely vectors and scalars; frame of reference, position and distance; average speed and average velocity; and acceleration and graphs of motion.

Initially, there were no English activities in the workbook; it was assumed that giving the learners an opportunity to read and write extensively would be enough. After conducting the pilot study, it was discovered that activities which specifically addresses language issues had to be included.

This was because there are academic words in science which are not necessarily science concepts. For example words like ‘rate’, ‘constant’, ‘magnitude’ and ‘instantaneous’ are academic words which are not science concepts and had to be addressed at the beginning of each unit. Science concepts include terms like ‘velocity’, ‘speed’, ‘acceleration’ and ‘displacement’ and these words were included in the physics activities. For example, the definition of velocity is “the rate of change in velocity”. If learners do not understand the meaning of the word “rate”, it will be difficult for them to understand the concept of velocity.

The workbook was used by the experimental group while the control group used their normal prescribed textbook. Learners in the experimental group were expected to complete the English activities on their own before each sub-topic was taught which implied that in each unit they were provided with some reading time.

They were required to find the answers themselves by reading through the material. This constituted an orientation to the topic before it was taught and discussed. It is a socially active construction of knowledge between the text and the learner.

3.4.2 PRE-TEST AND POST-TEST

Pre-test and post-test designs are widely used primarily for the purpose of comparing groups and measuring changes resulting from experimental treatments. Both the experimental and control groups were pre-tested, and both were post-tested, the ultimate difference being that only one group participated in the experiment. As already mentioned, the experimental group was taught with the workbook while the control group was taught with the normal classroom textbook.

The CAPS guidelines for preparing Physical Sciences examinations emphasise that questions in tests and examination should assess performance at different cognitive levels with the emphasis on process skills, critical thinking, scientific reasoning, and strategies to investigate and solve problems in a variety of scientific, technological, environmental, and everyday contexts. The instrument was designed following these guidelines. See Table 3.1 below from the DBE CAPS statement (2011: 108) which illustrates the weighing of cognitive levels that must be followed when preparing a test.

Table3.1: Percentages of cognitive level in preparing Physical Sciences test

Cognitive level	Description	Paper 1 (Physics)	Paper2 (Chemistry)
1	Recall	15%	15%
2	Comprehension	35%	40%
3	Analysis, application	40%	35%
4	Evaluation, Synthesis	10%	10%

The test was prepared out of 50 marks and based on the topic of mechanics. The physics paper slightly deviated from the guidelines mentioned above because the study focuses on language development in science learning. The relevant cognitive level for language development was cognitive levels 1 and 2. Most of the questions were based on these levels since the study deals with recalling and comprehending scientific words.

The test comprised three questions. The first question was a one- word item with five sub-questions worth ten marks in total and was based on recall (cognitive level 1). The second question comprised seven multiple choice questions worth 14 marks. The questions were a mixture of cognitive levels 1 and 2. The third question was open-ended with a mixture of cognitive levels 2, 3, and 4.

Table 3.2 below illustrates the weighing of questions according to the cognitive levels of a test. The main aim of the administered test was to find out if the implementation of the workbook improved learners' academic performance, especially their vocabulary and comprehension skills.

Table 3.2: Cognitive levels on the pre-test and post-test

GRIDS	Cognitive level 1	Cognitive level 2	Cognitive level 3	Cognitive level 4
QUESTION 1 (10 marks)				
Questions	**Cognitive level 1**	**Cognitive level 2**	**Cognitive level 3**	**Cognitive level 4**
1.1	2 marks			
1.2	2 marks			
1.3	2 marks			
1.4	2 marks			
1.5	2 marks			
QUESTION 2 (14 marks)				
2.1	2 marks			
2.2		2 marks		
2.3		2 marks		
2.4		2 marks		
2.5		2 marks		
2.6		2 marks		
2.7		2 marks		
QUESTION 3				
3.1 (a)		3 marks		
(b)		3 marks		
(c)		3marks		
3.2		1 mark		
3.3			4 marks	
3.4			6 marks	
3.5			3 marks	
3.6				3 marks
Total Marks	**12**	**22**	**13**	**3**
PERCENTAGE	**24**	**44**	**26**	**6**

Figure 3.1 below indicates the cognitive level percentages for the pre- and post-tests.

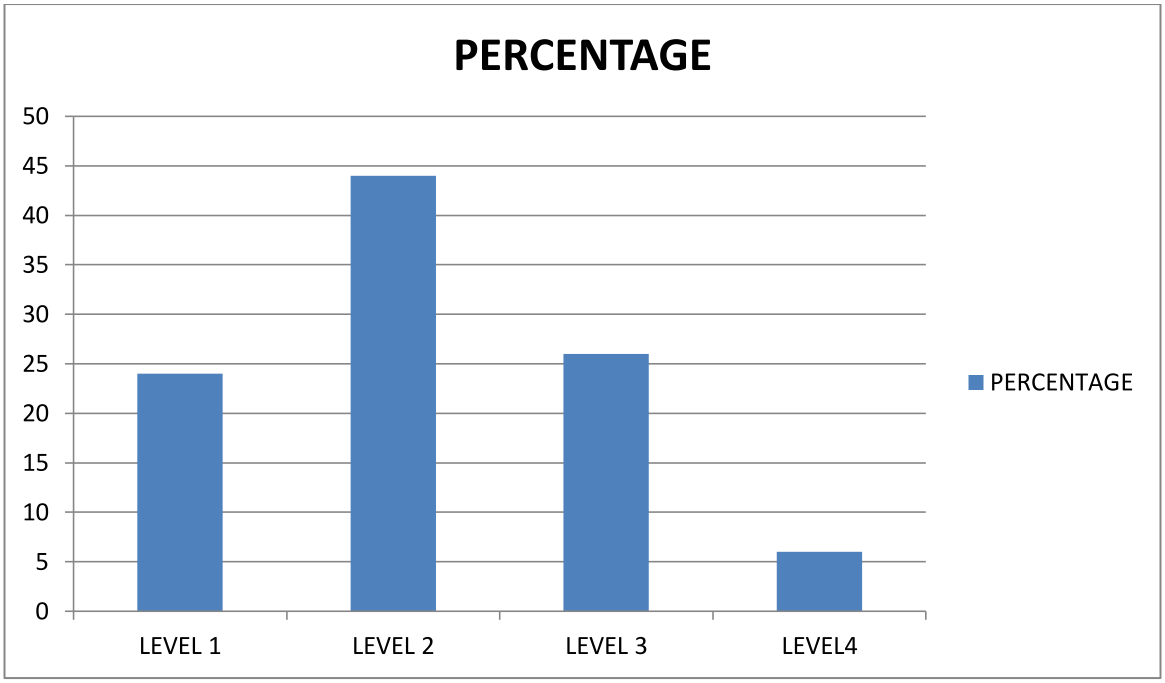


Figure 3.1: Pre-test and post-test percentage weights according to cognitive levels

The percentages from the table and bar graphs above indicate that most of the questions were mainly based on cognitive level 2 which entails comprehension, followed by cognitive levels 3 and 1. The total percentage for cognitive level 1 and 2 is 68% compared with the usual 50% illustrated in Table 3.1. Cognitive levels 1 and 2 deal with recalling and comprehending scientific knowledge and these are directly related to the language of science.

The reason for including more questions on recalling and comprehension is that the study is about integrating language lessons and science. Questions in these categories were included in the hope eliminate, to some extent, situations where student performance was influenced by Language difficulties. The test was moderated by Physical Sciences educators who work with the researcher with in the same circuit of KwaMhlanga North East (Cluster), and they all agreed which means that the test was standardised.

The head of the school's department of natural science also approved the test. It is standard procedure that any test written in a particular school must be approved by the HOD of department in that school.

3.5 Pilot Study

In the beginning of the third quarter of 2013 a pilot study was carried out in the nearest school with 56 Grade 10 Physical Sciences learners. The aim was to pilot the workbook and the test to be used in the main study. In addition, the researcher wanted to determine how much time the learners would need to complete the workbook. The only time available was Saturdays. But the learners were motivated because mechanics was the section they had to study in the third term and was one of the most difficult sections. The pilot study was also aimed at identifying challenging language aspects in the workbook.

On the first day the learners took the pre-test which was completed in an average of 45 minutes by most of them. During the pilot process it was discovered that some questions in the test were not well structured and there was a need to restructure them. After the workbook was given to each learner they started in unit 1 which was based on vectors and scalars. The researcher informed the learners that he expected them to write and discuss the questions in the unit for about twenty minutes and after that the whole class would discuss the findings. Learners were told that it was like English lessons where they have to read passages and answer questions.

Most learners did not struggle with the definition questions. They struggled where they had to identify quantities of vectors and scalars. The researcher had to intervene with the scale drawing and explain to them how to draw it. Most learners were motivated while working on this material and it was discovered that more time was required to complete each unit.

As discussed in section 2.3, the language of science has its own terms with which learners are not familiar. In each unit science-related terms or vocabulary that were difficult for learners to understand were identified, for example terms like 'magnitude', 'uniform', 'constant', 'rate', and many more.

This means that there has to be language activities as well as Physical Science activities in the workbook. It was however discovered that most of the questions in the workbook covered aspects of Physical Sciences but that there were no questions which explicitly addressed language issues and that this had to be remedied.

The workbook consisted of five units. Terms and words that were difficult to understand were identified and questions were designed that would encourage learners to read through the text and discover their meanings. For example, Units 1 and 2 each contained an Activity 1E and an Activity 2E; the "E" indicating that these were English activities to be completed before it unit was taught.

At the end of the pilot study the post-test was given and changes were implemented as discussed above. The pilot also assisted in discovering how to approach the questions, and which teaching methods should be followed. The learners actively participated and found the workbook stimulating and interactive. In most cases it dealt with content that was in their notes.

3.6 DATA COLLECTION

The study was conducted towards the end of the third term of the South Africa national school calendar. The first step was to receive permission from all 75 participants. Consent was also received from the Mpumalanga Department of Education. Then the principal of the school, the parents, and learners, and teachers of the classes in question were informed of the reasons for and goals of the study and given consent forms to sign. The learners were given the pre-test before the first topic was taught and were not removed from their classrooms at all throughout the study. All portions of the study were conducted via the content teaching of mechanics.

The subject content, as stipulated by the South African Curriculum and Assessment Policy Statement (CAPS) for Grade10, was not compromised in any way. Lesson plans were done as indicated in the CAPS documents and all the formal tasks which the learners were expected to submit were also not compromised.

The researcher incorporated a variety of language and comprehension strategies based on the Physical Science curriculum for the experimental group for three consecutive weeks. At the beginning of each sub-topic, as already mentioned, the learners were given time to read the notes in the workbook and answer the English activities. Their responses were discussed in the classroom with the educator and sometimes the activities were marked by the educator. When each sub-topic was introduced, the lessons were videotaped for both groups. This indicates that five lessons were videotaped in each group.

At the end of the third quarter, a post-test was given to the learners and they completed the same set of questions which they were given at the beginning of the study. The researcher marked both tests upon completion and an analysis of the results was conducted. A sample of 15 learners was randomly selected to participate in the focus group interview and individual interviews were conducted with two science educators at the school. The aim of the focus group interviews was to hear the views of educators and learners with regard to impact of language in science education. These interviews were also videotaped and transcribed and the data analysed.

3.7 VALIDITY AND RELIABILITY

Validity is the extent to which an instrument measures what it claims to measure. It is vital for an instrument to be valid in order for the results to be accurately applied and interpreted. Reliability is used to describe the overall consistency of an instrument; it is said to have a high reliability if it produces similar results under consistent conditions.

Section 3.5 outlines the implementation of the pilot study with the aim of ensuring that the workbook and pre- and post-tests were valid and reliable. The test was moderated by Physical Sciences teachers. The workbook was given to educators in the cluster where the pilot study was conducted and some changes were made in both the workbook and test.

3.8 ETHICAL CONSIDERATIONS

Ethical consideration is concerned with the fact that a researcher must be ethically responsible for protecting the rights and welfare of participants in a study. According to Awori (2003:58) ethical considerations “are paramount in any type of research”. Apart from protecting the informants, following research ethics also enables a researcher to maintain good relationships with the informants, and increases the credibility of the study:

The researcher obtained informed consent from the management of the school and the Provincial Department of Education to conduct the research study as part of ongoing professional development. The researcher is the Physical Sciences educator at the school and the Integrated Quality Management System (IQMS) requires educators to continuously develop themselves professionally in order to improve their classroom practice. The learners, teachers and parents signed consent forms stating that they were voluntarily participating in the study. The learners were assured that their marks would not be included in the data if they felt that they did not want to participate. The learners’ names were not included in the mark sheet but were replaced by numbers. Ethical clearance was also issued by the university to the researcher.

In this way participants could feel free to participate in the project and also felt that they would benefit academically. Finally the learners were told that they would be allowed to approach the researcher individually to find out how they performed in the test, and were ensured that the findings of the study would be available for them to view.

3.9 DATA ANALYSIS

Data analysis is a spiral that is equally applicable to a wide variety of qualitative studies (Leedy and Ormrod, 2005: 150). McMillan and Schumacher (2001:464) state that analysis begins as soon as the first set of data is gathered and runs parallel to data collection because each activity (data collections and interim analyses) informs and drives the other activities. In this study the data analysis ran concurrently with the data collection. The paragraphs below deliberate on how the data was analysed for both the quantitative and qualitative parts of the study.

3.9.1 QUALITATIVE DATA ANALYSIS

According to Henning et al (2004:102) there are many different ways of analysing qualitative study results, for example, content analysis, grounded theory analysis, discourse analysis, narrative analysis, global analysis, conversation and ethno methodological analysis, and computer-aided qualitative data analysis. They add that working with qualitative data, a researcher has many options on how to convert the “raw” data into final patterns of meaning. This depends on the methodological structure of the inquiry and the corresponding aims of the analysis procedures.

The qualitative data was analysed using the interpretative and coding system mentioned above. Setati (2011:126) states that interpretative analysis is “a process of close examination of data in order to find constructs themes and patterns that address the researcher’s research goal”. It is further emphasised by Miles & Huberman (1994:21) and Patton (1990:372), interpretative analysis reduces the volume of information, identifies significant patterns, and constructs a framework for communicating the essence of what the data reveals.

According to Setati (2011:126) (1994) researchers further analyse data using concrete flows of activities, namely data reduction, data display, and conclusion drawing/verification. This involves gleaning and reducing information in the process of finding out how the results of the analysis could be cross-checked and validated In the case of this study, qualitative data was drawn from the videotaped lessons of the experimental and control groups and from the focus group interview.

The videos tapes were transcribed to convert the audio and visual data into words. The transcriptions were then analysed with the aim of identifying patterns and similarities. The aim of the videos was to compare the teaching methods used in lessons that incorporated English language teaching and science content with and traditional lessons. In addition it aimed to identify characteristics of the experimental lessons as well as the traditional lessons.

The focus group interview was conducted to find out if language is one of the factors that affect learners' performance in physical science. A group of 15 learners from the experimental groups were interviewed and the interviews videotaped and transcribed. Two educators were also individually interviewed. Themes were established through the questions asked.

3.9.2 QUANTITATIVE DATA ANALYSIS

The data was analysed using descriptive statistics. McMillan and Schumacher (2010:149) state that descriptive statistics transform a set of numbers or observations into indices that describe or characterise data. Descriptive statistics (sometimes referred to as summary statistics) are thus used to summarise, organise, and reduce large numbers of observations.

The quantitative data in this study was obtained from the pre- and post-test scores and analysed by calculating the mean and standard deviations in each test for each group. The marks were also analysed using the pass requirements for the Department of Basic Education.

An Item analysis was done to check in which questions the learners performed better. Eaves and Erford (2009: 1) define item analysis as a general term that refers to the specific methods used in education to evaluate test items, typically for the purpose of test construction and revision. Item analysis is done to find out if there is a match between what is assessed and what is taught. In the context of this study the analysis was based on the understanding of physics concepts and therefore focused on questions 1 and 2 which deal with comprehension and recall.

3.10 SUMMARY

This chapter described the research design used in exploring the effects of incorporating language and science teaching. It was done by giving a detailed description and justification of the selection as well as use of the various data collection methods. These included selecting and locating the subjects, and data gathering via pre and post-test methods as well as a workbook. The researcher highlighted the differences between qualitative and quantitative approaches and explained why he opted to use both approaches instead of just one.

The following chapter presents the findings obtained from each of the research instruments. From these findings, a profile which incorporates English language teaching and physical sciences content teaching is created so that conclusions can be drawn and recommendations made.

CHAPTER 4

PRESENTATION AND DISCUSSION OF RESULTS

4.1 INTRODUCTION

In this chapter the results of the empirical research are presented. The aim of the chapter is to provide answers to the research questions posed in Chapter 1:

- What is the importance of incorporating English language teaching in science lessons?
- What are the appropriate language pedagogical practices which can be used in science classrooms that incorporate English language teaching and science?
- Can English language teaching in science classrooms be used as a tool to improve academic performance in science and to promote scientific literacy?

The data will be presented under the following headings:

- Outcomes of the lessons from the video tapes.
- Results from the focus group interview.
- Outcomes from the teachers' interview.
- Pre- and post-test results.
- Concluding remarks for the chapter.

4.2 OUTCOMES OF THE LESSONS FROM THE VIDEO TAPES

As it was indicated in chapter 3, five lessons were videotaped for the experimental group and the control group. This was done during the introduction of each Unit. In order to analyse the data from the videos, categories were established. The categories were informed by the research questions and the importance of such categories in teaching and learning. They were: teaching approaches, reading time during lessons, vocabulary and comprehension ability, and behaviour observed during lessons.

4.2.1 TEACHING APPROACHES

Observations of the videos revealed that various teaching methods were employed by the teacher in the lessons that incorporated language teaching in the science classroom. When introducing a new topic the learners were supposed to do the English reading task first. This is an extract from lesson 1 in Appendix 15 of the experimental group:

Teacher: We are about to start. Today we start with the topic of mechanics. What are we actually studying in mechanics?

Learner: How to fix things?

Teacher: How to fix things. Another one?

Learner: We study our environment.

Teacher: Our environment.

Learner: We study about engines.

Teacher: Engines. So it has to do with mobiles. In reality we are going to study about motion. Anything that is moving. Before I start with this I will give you time to do activity 1E. How much time must I give you? Now it is your time. (Silence for about ten minutes, learners working on activity 1E. All of them look focused on the activity. It is like they are writing a test or examination)

The extract above indicates that the few first minutes started with an activity. In order to answer the questions, the learners were supposed to read through the material. This method is called comprehension-based or text-based as discussed in section 2.4. The method is characterised by what is known as "the silent period". During these silent moments all the learners were actively engaged in the text; social constructivism took place between the learner and the text meaning that the learners constructed knowledge as they read the notes in the workbook.

This was followed by the question and answer method during which the teacher asked questions based on the completed English task. During this activity it was discovered that the learners were already familiar with many of the concepts as a result of completing the English task. Most of them could define the concepts easily.

After this the teacher employed the whole-discussion approach to clarify some of the concepts and formulae. The learners seemed to have some idea as it was not for the first time they encountered concepts like ‘displacement’, ‘velocity’, and others. This shows that the English task orientated them to the topic. The lesson continued and learners had to complete the task related to that topic after completing each unit.

On the other hand, the lesson in the control group (Appendix 14) started with a direct approach coupled with the question and answer method. The first 25-30 minutes of each unit was dominated by the teacher as he tried to introduce new concepts. During these moments the learners were passive and had to pay attention to what the teacher was saying. The question and answer method was employed when the teacher clarified the concepts using the context that the learners were familiar with.

The topic of mechanics deals with what learners see every day and the questions were context-based. For example when the teacher differentiated between displacement and distance, he used the context of a pilot and a car driver. In such instances the learners were actively engaged but it was difficult for them to comprehend the definitions of concepts which they encountered for the first time. Even when they were asked, they were unable to give the definitions of scalars and vectors in Lesson 1. After completing each unit the learners were given class work and sometimes homework as part of their assessment.

The above observation indicates that the lessons which incorporated English language teaching and Physical Sciences gave learners the opportunity to construct science knowledge through completing English comprehension activities in class. One of the activities of scientists include *reading* and learning from their reading. This is supported by Swanepoel (2010: 52) in section 2.4, who contends that early research considered reading a “passive, text-driven, meaning-taking process”, but that more recent research regards science reading as an “interactive-constructive” process (Hsu and Yang, 2007; Norris and Phillips, *sine anno*; Penney, Norris and Clark, 2003; Holliday et al., 1994). In order to ensure meaningful learning, teachers should mediate the interaction of students and text, providing meaningful purposes for reading and strategies for meta-cognition (Thiede et al., 2003; Ulerick, *sine anno*). This would be “active science reading”.

Moreover, when learners read they are, as already mentioned, able to relate what they see on paper to what is already in their minds; they are engaged in constructivism.

4.2.2 READING TIME DURING LESSONS

Reading time in the control group was limited to reading what the teacher wrote on the chalkboard, reading definitions from textbook and reading questions when doing class work. On the other hand learners in the lessons that incorporated language teaching and science spent more time of the lesson time reading. In addition to reading what the teacher wrote on the chalkboard, and reading from the workbook, the learners were also given an English task at the beginning of each new unit or topic which engaged them in reading. The learners spend about 10 -15 minutes completing these tasks on average.

In section 2.4 it was discussed that reading skills are extremely important for academic success. Lessons that incorporate science and language teaching give learners more reading time. It was also discussed that a skilful reader can acquire a high level of comprehension and overall higher order skills which are very important for academic success. Learners who are engaged in reading in science classrooms therefore have the opportunity to develop reading skills, especially skills related to science reading. Reading in science classrooms assists learners to move from frustration level readers to independent level readers.

4.2.3 VOCABULARY AND COMPREHENSION ABILITY

In the context on this study comprehension ability refers to the ability of learners to comprehend definitions and concepts in science. The observations indicated that learners in lessons that incorporated science and language teaching were more familiar with words and definitions than learners in the control group. They were more confident when talking because they read the words and definitions before they were taught. After they were completed the English reading activities they were able to comprehend more concepts. This is an extract from the video on day 1 from the experimental group (Appendix 15).

Teacher: A vector quantity is a physical quantity with magnitude only.

Learner: False. A vector's quantity has magnitude and direction.

The fact that when they were asked about vectors they were able to say that vectors are physical quantities with magnitude and direction indicates that they understood what they read; they were familiar with the words and their comprehension and vocabulary skills improved.

In section 2.6 it was discussed that the two most important processes involved in reading are decoding and comprehension, with the former referring to the translation of written signs into language and the latter to the absorption and understanding process whereby the aims of reading are met by giving meaning to the text. This indicates that the most important stage in reading is comprehension which translates into higher academic success and higher order thinking. However if a learners have higher decoding skills than comprehension skills, they may know the words without any understanding.

4.2.4 BEHAVIOUR OBSERVED DURING LESSONS

The observations indicated that learners in the lessons that incorporated language teaching and science were more motivated than those in the control group. Completing the English task motivated and they were more familiar with most concepts than the learners in the control group. There was also more interaction between the teacher and the learners. The extract below indicates this (Appendix 15):

Teacher: Physical quantity ne (Is it so?). When we talk about a physical quantity let's talk about the word physical. In physical science, especially in physics we deal with physical quantities. A quantity is something that you can measure. For example, temperature. You can be able to tell that in this classroom is 20^{o}C ne. What other quantities can you measure?

Learner 1: Mass.

Teacher: Another one?

Learner 2: Time.

Learner 3: The weight of a person.

Teacher: Another one?

Learner 4: Force.

This extract indicates that there was interaction between the teacher and the learners as they participated after completed the activity. The learners were used to doing the activities and the activities were stimulating and acted as reinforcement. The learners showed improved confidence when they talked about terms like ‘scalar’ and ‘vector’ quantities.

Since the learners were motivated, there were a few behavioural problems for example talking when they were not allowed to talk. When they were busy with the activities they did not even notice the teacher talking to them. This shows that the English activities were stimulating and encouraged them to concentrate.

On the other hand in the control group the teacher had to explain new concepts one by one. The learners were not familiar with the terms which were new to them. This is an extract from Lesson 1 of the control group:

Teacher: …..the pilot; because umuntu o hamba nge moto u yo phuma la nala and maga fika le a thole I board ethi Pretoria (The person with the car will follow the roads and the board will also direct him/her to Pretoria). So u ya bona ukuthi akadingi kakhulu I direction (So you can see that he/she does not need much direction). So that’s why ngithi kune zinto ezinye mauzi explaina you have to mention (That’s why I say that there are things when you mentioned) (Disturbance somebody borrowing a duster).ni ya ngizwisisa ne ngune zinto ezinye ma u khuluma ngazo you have to mention both the size and the direction (Do you hear me, there are things when you mentioned them you will need both magnitude and direction). Let’s say I have my aeroplane or helicpoter I want to go to Moloto uya bona a kuna ndlela e khomba ukuthi kuiwa njani e Moloto (You can see that there is no road in the sky showing direction to Moloto. The first thing

I will need to know what is the direction to Moloto and the second thing is how many kilometers to Moloto.) So I know that mangihambe 10km se ngise duze no ku fika e Moloto (I know that after travelling 10km I am nearly at Moloto). Then se ngiya bheka bheka langi yo lender khona (Then I check where I am going to land. But that's why other quantities need both direction and size. But when we talk about mass, there is no need to tell me about the direction of the mass, is there a need?

Learners: No.

Teacher: There's no need niyabona (is it so?). There's no need for you to tell me that you are 50kg to the south.

Learners: Laughing. No.

Comparing the extract from the control group with the one from the experimental group it is evident that the teacher was doing too much talking in the control group. This is because he had to introduce the concepts one by one. In the experimental group the learners discovered the new concepts from doing the English activities and there was no need for the teacher to do too much explaining.

In physics it is very difficult to introduce a new topic because you have to begin by explaining new terms one by one and the learners' concentration span is very low, especially in a school which is under-resourced. It was easier to introduce new concepts in the experimental group as I had to do less talking than in the control group. Most of the terms introduced to the control group were new as compared to the experimental group who discovered them from the English reading.

The fact that learners in the experimental group were motivated and actively engaged in the English tasks relates to Pavlov's classical conditioning which suggests that behaviour can be strengthened if it is followed by reinforcements or stimuli. The English activity was stimulating and therefore acted as reinforcement; such strengthened behaviours may cause permanent change in behaviour. Reinforcement sometimes does not need to be extrinsic, in the case of the study is intrinsic as it was brought by experience gained from engaging in a reading tasks.

4.3 RESULTS FROM THE FOCUS GROUP INTERVIEW

The focus group interview was conducted with learners from the experimental group and the focal point of the interview was to discover if the learners had experienced language-related problems in the learning of Physical Sciences. In addition, the focus group interview was aimed at investigating their experiences and finding out what they think about science in general. This section is discussed below according to the questions asked.

Question 1: What makes Physical Science difficult as a subject according to in your view?

Eight learners responded to this question.

Learner 1: The language that we are speaking at home and the language of science and the language we are speaking at school.

Learner 2: Ma unga stadishi sir. (If you do not study).

Learner 3: Ama calculations.(The calculations)

Learner 4: U studishe bese unga understandi. (Studying without understanding what you are studying).

Learner 5: Ukuthola amathishere a vilaphayo so. (If you have lazy educators).

Learner 6: Abo mam aba nga understandeki. Singa stadishela thina. If ever uMam u ya understandeka, ku zo ba lula uku zi bamba. (Teachers who teach but you find that we don't understand them, we can study but if the teacher is not understood it will be difficult to understand).

Learner 7: Taking the subject for granted.

Learner 8: Ukuthi sir ma u bona ukuthi umnyaka u yaphela, kuba auka sifundisi, usi fundisa masinyana u yabona. (If the teacher sees that the year is ending and he/she did not teach us and the teacher rush just to finish the syllabus).

It is noteworthy that the majority of the learners in this focus group replied to this question in their home language which suggests that they are not comfortable enough to express their ideas in English. Three of the respondents indicated that language related issues are one of factors that make Physical Sciences difficult. Learner number 1 clearly stated that the language is a problem. The second learner thought that one of the related factors is not studying the subject which is also language-related as it involves reading. The fourth learner mentioned studying without understanding as a factor. The other learners mentioned factors ranging from calculations to ineffective educators.

From the above it is clear that language is one of the contributing factors to high failure rates in the subject. This is confirmed by Wellington and Osborne (2001) who state that one of the major difficulties in learning science is learning the language of science which should be part and parcel of every lesson in the science classroom. Science teachers must be aware of the fact that language is a major barrier to learning and that language cannot be ignored in the science classroom.

Question 2: Do you think that language affects the pass rate in science?

Learners in chorus: Yes.

Learner 1: Ga e tshwane le language ye re e usago ko gae, dilo tsa teng di a difara. (The language is not like the one we use at home, it is different).

Learner 2: Ama words akhona, like they are more complicated, ukuthi u nga wa bamba entlokweni yakho vele, so if wena u ya studisha like in every day, u wa practise like by talking them no ma ungu bani like i centre so, masi wa khuluma si communicate ngawo I think things will be very easy. (The words are complicated, they are not easy to remember, but if you practise them like in group by speaking them then it will be easier).

Learner 3: Be ngi yo khuluma nje ngaye mara ngi funu uku adda. If ever abdisi and asi khone kuwa pronouncer , vele angeke siwa bambe. (I was going to say what she is saying but if this words are difficult, we cannot pronounce them, then we cannot remember them).

Learner 4: I wanna say like if you ask them to explain something, then the teacher will use mother tongue not in simple English, I think it will be simple if he or she explain in simple English because in our mother tongue we will not be able to put it in English.

Learner 5: Key a greeya sir. Gabotse each and every teacher ahlalose, entlek the whole school e swanetse e be le language e ee berekisago in class. (I agree sir, actually each and every teacher must explain, the whole school must have the language that it is using).

The above responses indicate that most learners agree that language affects the pass rate. Studying involves language and is therefore fundamental to the language of teaching and learning. The learners mentioned that if science can be studied by practising and talking, it would help. They also mentioned that the language of science is not the same as the language they use at home and at school. This was supported by Fang (2006) in section 2.3 who states that one of the obvious features of scientific language is that it contains technical words that rarely occur in children's everyday informal spoken interactions.

Question 3: What language would you prefer to study science with?

Learner 1: English.

Researcher: Why do you prefer English?

Learner 1: Is because go nale mantsu amangwe Oka se kgone go a pronouncer in our mother tongue mara aka English. (Because some of the science words you cannot pronounce them in mother tongue).

Learner 2: The same.

Learner3: English.

Researcher: English. OK reason.

Learner 3: Because sir is like ke language e re e berekisago go communicator le batho and diquestions tsa physics di tla ka sekgowa. (It is the language that we use to communicate with people and questions in science are asked in English).

Learner 4: Keya dumela (I agree).

Researcher: Which language do you prefer?

Learner 4: English.

Learner 5: Mina sir ngi prefer I English ngoba eish isiNdebele , u yai bona I H_2O iH_2O ngeke wa I biza nge sindebele. Sir u ya bona nawe. I hambili ou. (I prefer English sir because you cannot pronounce H_2O in isiNdebele).

Learner 6: Oh me I will prefer English.

Learner 7: Lenna ke prefera because the most language ere ka communicating ka yona re kgono utlwisisa ke English. (I prefer English because when we communicate in most cases we use English).

Learner 8: Mina ngi prefer iEnglish just because i physical science ina amaelements. (I prefer English because Physical Science has got elements).

Researcher: Yah.

Learner 8: Amagama wa khona azoba difficult if ever ngi wa sebenzisa nge siNdebele cause ngingumdebele angeke ngithi hambili ou. I better say H_2O. (The words will be difficult in isiNdebele, I cannot say 'hambili ou' I rather say H_2O).

Learner 9: English.

Learner10: English.

Learner 11: Home language.

Leaner 12: English.

Twelve learners responded to this question and only one learner indicated that she prefers home language as the language of learning and teaching. Most learners confirmed that there is no way they can learn Physical Sciences in their own language and prefer learning the subject in English rather than in their mother tongue.

South Africa has eleven official languages and if learners are to learn their content subjects in home languages, the country would not be able to cope with the financial demands required to implement the process. South Africa is currently facing a crisis because of a shortage of mathematics and Physical Sciences educators; it will be even more difficult to get educators who will teach in specific languages. Furthermore African languages are not yet sufficiently developed to deal with the vocabulary demand in science disciplines. For example how do you refer to ‘chemical equilibrium’ in IsiNdebele? One of the learners mentioned the issue of pronouncing the formula H_2O in IsiNdebele.

This indicates that as a country we are stuck with English as the language of teaching and learning for at least two or more decades and that there is a need to come up with solutions to deal with the language of teaching and learning. The Department of Basic Education has introduced a fourth subject in the foundation phase, namely English First Additional Language for learners whose mother tongue is not English. However, this is not enough because the problem will still emerge in intermediate, senior and further education and training phases.

Question 4: How are you taught reading in the English classroom? What type of articles (e.g. newspapers) do you use when you learn reading strategies? Do you sometimes read science articles in the English classroom?

Learners (few learners): No.

Learner 1: Yes we do.

Researcher: Le ithuta ka eng English ko claseng gale i thuta reading what type of articles do they use?

Learner 2: Short stories, poems, and akuna science. (Short stories, poemsa dn there is no science)

Learner 3: Mina ngithi ikhona. (They are there).

Learner 3: OK I can see some of the stories are having science cause like we like in this other stories we learn about hymenia, hymenia this disease, we learned about the person who is diagnosed with bleeding gastric, we did not know that , and that is part of science.

Learner 4: Think sir namanje you can say water and you can transfer it in English angithi ku Physical Science they can take H_2O and they say ibale nge gama so kushokuthi siyayifunda.

Learners: Some.

Researcher: But most of them eh what do you think, are they general or are they related to science?

Learners: General.

Most learners indicated that short stories are introduced when they are taught reading in the English classroom. The researcher asked if the articles were science related and most of them answered “no”. Some learners indicated that there was at least one article which was related to science. However it was clear that most of the articles used in the English classroom were not related to science.

The importance of reading in the science classroom cannot be underestimated. Reading academic material like a science textbook is not the same as reading a daily gossip newspaper or novel. Reading science academic material is a skill that must be taught in the science classroom. Most science educators are concerned with completing the syllabus rather than paying attention to language which is a major barrier.

Teachers forget that language is a tool of thought and that most learning in class happens through language. They also often forget that when they are at home, the learners hardly ever communicate in English, let alone the language of science.

Question 5: Do you think that incorporating language (reading strategies in the science classroom) can help you to understand the subject better?

Learner 1: Yes.

Learner 2: Yes.

Researcher: Maybe who will like to expatiate more about it kuthi how will it help you. Unga funu ku qwalisela ukuthi izomuxeda njani. (Who can try to explain how it will help?).

Learner 7: It will help us like if we read those stories and you will read them from lower grades until matric those things will be there or we won’t forget them and if they are in physics they will be fine.

Most learners agree that incorporating language teaching in the science classroom will assist them in understanding the subject better. One learner felt that if English is incorporated in science classroom they would be able to understand most of the content.

The Department of Basic Education (see section 2.4) remind Physical Sciences teachers that they are not only science teachers, but also language teachers across the curriculum. However the problem lies with the implementation part of this sentiment. How are they supposed to teach language in the science classroom?

This can be done by designing language tasks to guide learners in the reading of their textbooks. It is an open secret that top achievers in science are learners who are able to read effectively and understand the concepts they read about.

Question 6: Do you think that Physical Sciences have got its most distinct terms from other disciplines? Give examples.

Learners: Yes.

Researcher: Ngifuna ningiphe nama examples (can you give examples of such terms) such terms la nibona ukuthi la akhona akhona ku physics but in real live ani wa thole. OK.

Learner 1: Igama leli i Stoichometric, u yalibona, ngilazi nge physics kuphela. (The word that says ‘stoichometric’ I know it from physics only)

Learner 2: Chemistry.

Learner 3: Double bond.

Learner 4: Carboxylic group.

The majority agreed that Physical Sciences has its own specialised terms and gave examples of words that rarely occur in their daily lives like ‘Stoichometric’ and ‘double bond’.

Research indicates that science education involves dealing with familiar words like ‘energy ‘and giving them new meanings in new contexts. Consider ‘element’, conductor, ‘cell’, ‘field’, ‘circuit’, and ‘compound’. This is made worse because many of the terms in science are metaphors. For example a ‘field’ in science is not really a field. Another category of language which science teachers (and many other teachers) use has been called the ‘the language of secondary education’. The list includes ‘modify’, ‘compare’, ‘evaluate’, ‘hypothesise’, ‘infer’, and ‘recapitulate’, and so on. These are words used by science teachers and in exam papers but rarely heard in playgrounds, in pubs, or at football match (Wellington and Osborne, 2001: 5).

Question 7: How does the language used in Physical Sciences compare with language used in other disciplines? Give examples. (Which language is difficult).

Learners: Physical Science language.

Researcher: Physics, Physical Science language. Eh sesi?

Learner 1: Yes It is more into science, into science thing, ayi khulume nge reality ngezinto eziyenzeka empilweni zethu. (Yes it is more into science; it is not about reality and about things that happen in our lives).

Researcher: okay okay i different ne? (Okay you mean it is different?

Learners: Yes.

Learners indicated that the language used in Physical Sciences is difficult compared to the language used in other disciplines. One learner mentioned that the language used in Physical Sciences is not related to real life situations. Prophet and Badebe (2006:239) in section 2.3, also confirm that to learn in the domain of science, a learner has to acquire a new language and without this language, understanding cannot be achieved.

Yet even if learners can use scientific terms in reading and writing, it does not mean that they understand them. A learner recently asked me after writing an examination how to calculate magnitude, and asked for the formula. The learner missed the fact that it has to be the magnitude of a certain physical quantity, for example a magnitude of electrostatic force. This made me realise that the problem was language-related.

Question 8: How best do you think Physical Sciences should be taught?

Learner 1: If ever like they teach it from Grade 4, they teach it from Grade 4, uyi khethe from Grade 4, ukhupuke nayo njalo. Hayi ukuthi sifunde i social science last year. Ku xono ukhule u yazi u kuthi i physics le, ukhule nayo'. (They must introduce hysical Sciences in Grade 4 so that we grow up knowing that there is physics).

Learner 2: Maybe Grade 4 e fase thata a e ka thoma ka Grade 6. (Maybe Grade 4 is low, introduce it in Grade 6).

Learner 3: Masingakhuluma ilanguage ye science, si increase siyikhulume ema Khaya sikhulume yona nje ngabantwana be science. I think izoba better. (If we can talk the language of science even at home then it will be better).

Learner 4: Physics eswanetse go ba le di period tse dintsi go swana le Maths. (Physics must have many periods like mathematics).

Learner 5: Ebe le di experiment tse dintsi. (It must have many experiments).

Learner 6: Like a teacher even a teacher is talking to us like Physical Science way not the English way.

Learner 10: Like I wanted to say the number of bana ka mo classeng maybe ratio ya gona ebe 1: 30 or 1: 20. (I wanted to say that the number of learners in class must be a ratio of 1: 30 or 1: 20).

Ten learners responded to the question and most of them mentioned introducing the subject at an early grade. This indicates they were not aware that they were doing Physical Sciences incorporated in Natural science in the lower grades, notably from Grade 4. Learner numbers 3 and 6 felt that the teacher must use the language of science when talking to them. Most learners felt that there should be experiments in science teaching while some learners felt that the lessons for Physical Sciences should be increased.

Most learners perform poorly in questions that require them to give an explanation or reason. Even though they understand the concepts, to put it in writing is another challenge. Howe (2003:8) confirms the above indicating that native English speakers performed best (25 points out of 40) in mathematics and science while Afrikaans speaking learners attained the next highest score (21 points out of 40). Scores were very low and poor for speakers of African languages. The results show that learner proficiency in English, the language spoken at home, and the language of learning in the classroom all have direct effect on learner performance in mathematics and science (Howe 2001:9 in Muzah, 2011: 84). This indicates that language teaching in the science classroom must be prioritised if learners are to succeed.

Question 9: What else would you like to add?

Learner 1: More qualified teachers to teach science sometimes you find you find ukuthi abanye abo teachere aba si qualified and they give you a very big, inkinga vele. (There must be more qualified educators because teachers who are not qualified they give us lot of problems).

Learner 2: Kumele si be na ma poster siforme na ma science group like hy ukuthi si stadishe. (There must be posters and we must also form science groups so that we can study).

Learner 3: Giving certificates to learners who perform well in physics. This will motivate like other learners to pick up their socks.

Learner 4: Ya swana le ya gagwe. (I was going to say what she said).

Learner 5: Ne ke nagana gore mathishere are rutang like aseke a berekisa, like bona ba tseba ka ga yona, like ga bare explainela ba se ke ba re felela pelo, bare explaine pila ka English e simple. (I was thinking that teachers who teach us, they must not use, like they know more about physics, when they explain they must be patient with us, they must explain in simple English).

Learner 6: Also like if our teacher can teach only in grade 10 not teaching also Grade 9, because you find the teacher running to Grade 9.

Learner 7: Kufuneka ku be ne trip yo kuya eskolweni esinye , umnyaka lo azange sibe ne trip. (We must have a trip and visit other schools this year we did not have a trip).

Learner 8: Go swanetse go be like library so that re be le more books tsa science. Library. (The must be a library so that we can have more science books).

Learner 9: Go swanetse ba efe nako gore re kgone go utlwisisa. (They must give it more time so that we can understand it).

Learner 10: Ko classeng ya science go swanetse go be le TV ba kentshe CD bare bontshe nthwe re ithutang ka yona. (There must be a television in science class so that they can show us what we are learning).

The learners felt there must be posters in the science classrooms and better qualified teachers. They also thought that giving certificates to learners who perform well in science would be a good idea. The issue of resources like a library and television was also mentioned.

The perceived need for posters in the science classroom is also related to language. Posters are one way that teachers can use the language of science to familiarise learners with strange and metaphoric words. For example the periodic table of elements can be put on the notice board so that learners can become familiar with the different elements and not confuse the symbol for potassium thinking that is “P” rather than “K”.

Another challenge is that learners expect teachers to explain concepts to them instead of discovering the concepts themselves from doing the English activities. There is a saying that goes “teach a man how to fish rather than give a man a fish”. This is similar to the situation above. The teacher must be like a navigator rather than a provider of knowledge. A navigator shows the driver a road to a particular destination, but it is the responsibility of the driver to reach that particular destination. Teaching is not telling; learners have the responsibility to construct their own knowledge through engaging with the text.

4.4 RESULTS FROM TEACHER INTERVIEWS

This section discusses the results from of the teachers’ interviews. Two science teachers from the same school where the study was conducted participated in individual interviews. The interview schedule consisted of twelve questions. The data was analysed according to the questions. The first educator has five years experience teaching Physical Science and the second educator has ten years experience teaching the subject.

Question 1: How does teaching Physical Science compare with teaching other subjects?

Teacher 1: Hm I can say teaching Physical Science, is more challenging than teaching other subjects for instance if one has to teach Physical Science the experiments has to be used, but let me take eh the language, language can be theoretical but science cannot be theoretical, it should be theory plus the experiment the learner will understand Physical Science better when experiment has been done.

Teacher 2: Yah eh teaching Physical Science compared with other subject is that when you are teaching Physical Science the teacher should not be lazy, you must always be reading, calculating, practicing so that you don’t forget so that when go to class you are going to teach, you can be able to deliver.

The responses above indicate that both teachers find teaching Physical Sciences more challenging than teaching other subjects. The first teacher mentioned the practical aspects of the subject as the cause of the difficulty. The second teacher felt that teachers who teach Physical Sciences must not be lazy as they are expected to read and practise all the time.

The implications are that if teachers are expected to read all the time, learners will find it even be more difficult as they are still novice scientists. This means that learners must have the necessary skills to read and understand science content. The practical aspects of the subject are also related to language; for learners to do practical work they need to understand the terms.

Question 2: Does this make teaching Physical Science easier or more difficult to teach than other subjects?

Teacher 1: OK, let me respond according to the way two terms that have been used, the easy part and the difficult part I can say teaching science will be difficult if there are, if the school doesn't have the apparatus maybe the school is poor and it's a disadvantaged school but it can be easy if the apparatus are there and learners will experience the easy part of doing science.

Teacher 2: No teaching Physical Science is more difficult to teach you must always be doing practicals, reading, calculating, so is more difficult to teach Physical Science than other subject.

Both educators still agree that Physical Science is more difficult to teach than other subjects. The first teacher still mentioned the practical aspect and the second teacher again mentioned that it is difficult to teach because teachers must do practical work, read, and calculate all the time.

It is evident that the subject demands more time from teachers. The responses also confirm that scientists are not always in the laboratory doing practical; they also spend more time reading and doing calculations. This was confirmed by Teacher 2 above. If educators spend more time reading, learners as novice scientists are expected to do the same which means that they will need the necessary skills to engage in science reading.

Question 3: Do your learners see Physical Science as a difficult or easy subject to learn? What do you think make them think so?

Teacher 1: I will go back to number 3 on the difficult and the easy subject , some will see the science part as a difficult one but some will also see it as an easy one for those who see it as difficult subject are the lazy ones because of their laziness, sometimes the laziest learners you can also find them in class are those who will see the subject as difficult one because of their laziness, but the hard workers they find it easier because they give themselves time to go through everything that is in science.

Teacher 2: No the, because, Physical Science is not difficult but it is eh challenging but these learners they are lazy to read and practice that's why they find difficult in Physical Science but is not difficult but it is challenging.

The first teacher felt that lazy learners will find Physical Sciences difficult and that hard working learners will find the subject easy. The second teacher felt that Physical Science is not a difficult subject, but concurs with the first teacher that is difficult for lazy learners. Both educators thus agree that the subject needs learners who are dedicated to their school work. In most cases learners who do not read are not motivated to read because they do not understand what they are reading.

Question 4: Do you see Physical Science as a difficult subject? Explain.

Teacher 1: Ah I can say for me science is not easy I will say is much challenging because from time to time one has to teach this subject without the apparatus we have already mentioned above and you will have to teach the theory part we cannot tell the learner about the certain colour of a chemical that they never seen. Some learners do not know the chemicals.

Teacher 2: No it is not difficult but is challenging you need, Physical Science don't need a lazy teacher, you need a teacher who is always hard working.

Teacher 1 agrees that Physical Science is a difficult subject due to lack of resources to perform practical work. Teacher 2 disagrees that Physical Science is difficult but finds it challenging. The laziness of the learners is related to learners who do not read enough. Many educators mention that hard working learners are the only ones who will succeed in Physical science forgetting that some learners may not be committed to their studies due to lack of reading skills, especially reading science academic material.

Most universities now do not admit learners who get less than 50% in the language of teaching and learning because they have realised that many students fail at university due to lack in proficiency in the LoTL. This also applies to science learning which has its own language. Learners who are not proficient in reading science material usually do not succeed.

Question 5: What makes Physical Science difficult as a subject according to your view?

Teacher 1: Hm I will say previously we have been told that Physical Science is difficult and then we have got this I don't know whether I can call it a myth or what that say science is difficult because is like we have planted this information in our head or our mind that science is difficult even though is not difficult.

Teacher 2: Yah the subject is that the practical aspect makes the subject difficult.

Researcher: OK the practical aspect of the subject, ok do you think is this the only factor that makes the subject to be difficult for these learners:

Teacher 2: Yah no at the same time Physical Science also is one of the subject that need more resources, so if you are teaching you don't have resources is going to be more difficult for to tell the learners.

According to Teacher 1, it is a myth that Physical Science is a difficult subject while Teacher 2 mentioned the practical aspect as challenging. In addition Teacher 2 mentioned lack of resources. Most educators still think that language proficiency in the science classroom will develop by itself but this is not correct. They forget that everything in learning happens through language and as long as language issues are not addressed learners will continue to perform poorly in science subjects.

Question 6: Does language have an effect on the pass rate? Explain.

Teacher 1: Yah I will say the language also has an effect on the pass rate because if, If a Ndebele child has to do the science with English some of of the terms or the words cannot be found in the western or English language though you found that learners will find it difficult to understand because for instance they will take, they will know this, what can I call it, it's like a medicine, they call it umthuma ne.

Teacher 2: Yes the language affect because most of the question is English so our learners they find problem with the English language sometimes they don't understand the English so they find difficult to answer those question.

Both educators agree that language has an effect on the pass rate. Teacher 2 mentioned the fact that questions are asked in English and most learners have problems as they do not understand English. The teachers thus acknowledge that language affects the pass rate and that incorporating language teaching and science can assist learners in understanding the subject better.

Question 7: In which language would you prefer learners to study science?

Teacher 1: Hm in their home language, depending on the environment they are living in like for instance let us take Sun-City the majority of the learners are Ndebele ne.

Teacher 1 continues: So, in Sun City they are living in the former KwaNdebele and majority of the people here are speaking Ndebele they will find it more easier to them to understand even the Pedi speaking learners they do understand the Ndebele language but go to Nelspruit, even though is the same Province Nelspruit is Mpumalanga the learners there I should think they can use the Swati language because they understand the Swati better than any other language it will depend on the type of environment they are in.

Teacher 2: I will prefer English, but the English they must get good foundation so that when you are, when they are in secondary level there will be easy to read and understand the content.

One teacher preferred home language as the language of learning and teaching while the other one preferred English. Teacher 1 indicated that it will make the subject easier if it was learn in home language. However Teacher 2 felt that English is better as long as learners receive good foundations so that when they come to secondary school it will be easy for them to learn content. But even if they have good foundations in English they will still have to be taught the necessary skills to read and write in the science discipline which is a discipline with its own language.

Question 8: Do think that English language teachers must use science articles when they are teaching reading in their classroom?

Teacher 1: Ah yah, I think, I think that they can use that science articles but only to find that it will also be difficult for them because they cannot use science hence they did not do science at school it will be just like photo frame pasted on the wall because they will not be able to understand any type of the thing pasted on that article.

Teacher 2: Yes, because they must use those articles so that eh those learners who are doing science they will not find it difficult when it comes to only science aspects, they will know that in English also there is science hence also is there.

The above responses indicate that both educators agree that science articles must be used in the English classroom. However one educator felt that English educators would have a problem understanding science articles since they did not do science at school. This indicates that the best solution for science teachers is to incorporate language teaching in their classrooms to narrow the language gap that science learners have.

Question 9: Do you think that incorporating language (reading strategies in science classroom) can help learners in understanding the subject better?

Teacher 1: Ah I think that if they can incorporate or integrate this language it will be easier for them because hm I should think that all the learners are doing the language at school the English language if this thing, if the science is integrated in their reading in their classroom it will be easier for them find that if for instance they are given the comprehension that deals with science I should think that they will find it better or much easier for them to understand this subject much easier because they will be free to ask any question concerning them.

Teacher 2: Yes because you know when you talk of science, science also goes with language like for example when doing practicals you must explain like when you are writing the methods you need English when you explain to somebody also you need English so if they are incorporative is going to help those learners.

The above responses indicate that if science is incorporated with language lessons it will be easier for learners to understand the content. The question is, how can language lessons be integrated with science? This can be done by designing language activities that engage learners in science reading and writing.

Question 10: How does the language used in Physical Sciences compare with language used in other disciplines? Give examples.

Teacher 1: Hm I can say sometimes they are the same this terms that are being used compared to the language sometimes they are not the same like for instance I will say take a Grade 10 given the type of investigation, let us say they are running an experiment ne , if they are running an experiment or they are doing an experiment they will be an investigative question they have to go through the comparison, the research all those the hypothesis only to find that if they has to do science there will be a hypothesis it won't be the same as those used in language so sometimes I will say some words are more difficult in Physical Science to understand than in the English part or in the language.

Teacher 2: No the terms in Physical Science is different because those scientist there are different terminology that they are they are using. So is different is not the same.

Teacher 2 continues: Yah when we talk of the Newton's laws when we talk about Newton everybody knows that we mention Newton we talk about science but when we talk about the other terms everybody knows that this is not science term, when we talk of Newton's laws those unit, then we know that this is science.

Both educators that agree that most of the science terms are difficult compared to other disciplines. For example Teacher 1 mentioned the processes followed when learners are doing an experiment and Teacher 2 mentioned Newton's laws as an example. If science terms are more difficult to understand it means that some interventions are needed to close the gap. This can be done by incorporating some language strategies in the science classroom.

Question 11: How best do you think Physical Sciences should be taught?

Teacher 1: I will say hm, the strategies that can be used in teaching science the learners must be given the research type question, they can also find hm, install the Internet on all the science schools for the learners so that they can also communicate with the other expertise that teach science like you can see hm we have got the channel that do science if they learners find the difficulty because sometimes the teachers can also have the problems so he or she will feel free for learners to communicate with the other expertise outside the teaching environment.

Teacher 1: Yes the best way Physical Science should be taught one is that the school must get the good resource at the same time teacher also must be well equipped, must be knowledgeable at the same time the learners must be cooperative with the teacher. Because the teacher can teach well if the learners they are lazy or they find it difficult to read or study is going to be difficult to the teacher and the learner.

Teacher 1 mentioned using the Internet so that learners can have many options if they encounter difficulties. Teacher 2 mentioned the issue of resources, knowledgeable educators, and other learners who may be able to provide solutions. This indicates that for learners to succeed they must not find it difficult to read.

Question 12: What else would you like to add?

Teacher 1: OK I will say science is a very hm enjoyable subject. People must not find science as a difficult subject like I always said above because like I have said people have this theory that science is difficult the learners just come and say I am here to take chances because someone has told me that science is difficult.

Teacher 2: Yah what I want to say is that science is not difficult is challenging so but if in educators I wanna talk of educators, educators they should not be lazy at the same time you must always be reading, practicing attend workshops at the same time the regional office must organise workshops for educators so that will know new content, they will know what is going on and when it comes to the, learners also, learners also they should not be lazy they should not think that the subject is difficult is challenging but not difficult.

The responses above indicate that both educators believe the subject is not difficult but it needs learners who able to study and educators who are dedicated. The point of departure here is that reading is important in the domain of science. This is important for both educators and learners. For the teacher it is important so that they can present lessons effectively, and for the learners it is important so that they can cope with the vocabulary demand necessary for learning the subject.

In summarising the results from the teachers and learners interview it is clear that both educators concur that Physical Sciences is difficult to teach as compared with other subjects. However both educators do not agree that Physical Sciences as a subject is difficult for learners, and agree that the subject needs dedicated learners who are not lazy to read. The interesting part is that they think it is difficult to teach but not difficult for the learners. On the other hand most learners agree that Physical Science is a difficult subject.

Both educators agree that language affects the pass rate in science and one educator indicated that she would prefer learners to be taught in their mother tongue while the other prefers English as the LoLT. Most learners indicated that they prefer English as LoLT.

4.5 PRE-TEST AND POST-TEST RESULTS

The learners were divided into two groups. About 75 learners initially participated in the study. There were 37 in Group 1 which was the control group and 38 in Group 2, the experimental group. However the data for reporting purposes was drawn from 34 learners from each group with a total of 68 learners. The reasons for withdrawing the data of seven learners is that some of them did not write the pre-test while others did not write the post-test. Some of the learners were absent when the pre-test was written and some of them were absent when the post test was written.

Group 1 learners were the control group and were not taught using the workbook that incorporated language teaching and physical sciences. Group 2 was the experimental group and were taught using the workbook that incorporated language teaching and Physical Sciences. Both learners were given the pre-test at the beginning of the topic and the post-test after completing the topic.

The tests were administered under standardised conditions for both groups and the learners were not allowed to refer to any reading material when writing the test. The tests were administered in the school with one learner at each desk. The researcher was the invigilator. The duration of the test was 1 hour and added up to 50 marks in total. The duration was estimated from a Grade 12 Physical sciences question paper of 150 marks which lasted 3 hours implying that a 50 marks test would take 1 hour. Most of the learners finished between ten minutes and thirty minutes for the pre-test and about 45 to 60 minutes for the post-test.

Descriptive statistics was used to analyse the data. According to McMillan and Schumacher (2010: 149):

> …descriptive statistics (sometimes referred to as summary statistics) are thus used to summarize, organize, and reduce large number of observations. Usually the reduction results are derived from mathematical formulae to represent all observations in each group of interest.

The mean scores and standard deviations for each group were calculated and compared. In addition, the pass percentages were analysed using the pass requirements for the Department of Basic Education. Lastly an item analysis was done to find out in which type of questions the learners performed well. The table below summarises the data:

Table 4.1: Summary of results for the pre-test and post-test

GROUP 1						
TESTS	**NUMBER OF LEARNERS**	**MEAN***	**STANDARD DEVIATION***	**Achieved 30% and above**	**Percentage pass (30% and above)***	**Percentage pass (40% and above)***
PRE-TEST	34	10.24	6.30	0	0	0
POST-TEST	34	31.35	11.32	14	42.42	26.47
GROUP 2						
TESTS	**NUMBER OF LEARNERS**	**MEAN***	**STANDARD DEVIATION***	**Achieved 30% and above**	**Percentage pass (30% and above)***	**Percentage pass (40% and above)***
PRE-TEST	34	9.59	5.96	0	0	0
POST-TEST	34	45.71	21.41	25	73.53	58.82

*scores calculated in percentages

The table above indicates that there was an improvement in marks for both groups when comparing the pre-test and the post-test. For Group 1 the mean score increased from 10.24% to 31.35%. Group 2 moved from the mean score of 9.59% to 45.71%. This indicates that the pre-test acted as a bench mark for the post-test and that learners had little knowledge about the topic before they were taught about it. However the results indicate that Group 2 learners performed better than Group 1 registering a difference of 14.36%. This is summarised in Figure 4.1 below.

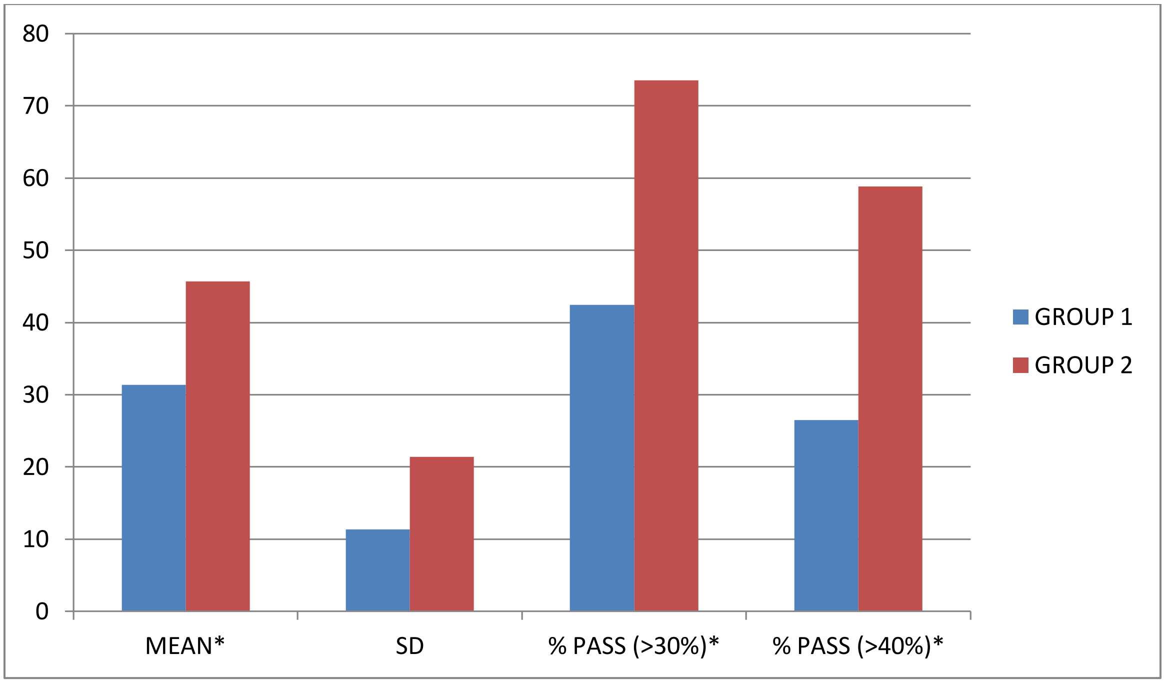


Figure 4.1: Comparison of Group 1 and Group 2 summary of scores for the post-test

The pass requirements for Physical Sciences prescribed by the Department of Basic Education is 30% and above. The chart above indicates that the percentage of learners who achieved 30% and above for Group 2 is at 73.53% for Group 2 and 42.42% percent for group 1. The standard deviation also indicates that the number of learners who scored above the mean for Group 1 is lower than that of Group 2. In addition the chart indicates that the percentage of learners who scored 40% and above in Group 2 is higher than that of Group 1. This indicates that the workbook that incorporated language teaching and Physical Sciences contributed to higher academic performance for Group 2.

In section 2.4 it was indicated that “language makes it possible for us to understand and make sense of the world of Science by: providing a cognitive framework of concepts”. Therefore incorporating language and science can assist learners to understand concepts better by providing a cognitive framework for science concepts. This will translate into higher academic achievement if implemented and planned carefully. The results indicated without doubt that academic achievement can be improved by lowering the language gap in science classes.

To substantiate the above statement, the table below indicates the levels of achievement for Groups 1 and 2 for the post-test.

Table 4.2: Group 1 post-test performance in terms of levels, minimum, and maximum scores

Levels	Number of learners	Minimum score	Maximum score
1 (0-29)	20	18	28
2 (30-39)	5	30	38
3 (40-49)	7	42	48
4(50-59)	0	-	-
5(60-69)	2	60	64
6(70-79)	0	-	-
7 (80-100)	0	-	-
Overall	34	18	64

Table 4.3: Group 2 post-test performance in terms of levels, minimum, and maximum scores

Levels	Number of learners	Minimum score	Maximum score
1 (0-29)	9	18	28
2 (30-39)	6	32	34
3 (40-49)	6	42	46
4(50-59)	5	50	58
5(60-69)	2	62	68
6(70-79)	2	74	76
7 (80-100)	4	80	96
Overall	34	18	96

The tables indicate that the minimum scores and maximum scores for Group 1 and Group 2 range from 18-64% and 18- 96% respectively. The number of learners who achieved a score of 80% and above in Group 2 are four as compared to none in Group 1. This indicates that Group 2 performed better in the post-test as result of incorporating language teaching and physical sciences in the Group 2 classes. The results are summarised in Figure 4.2 below.

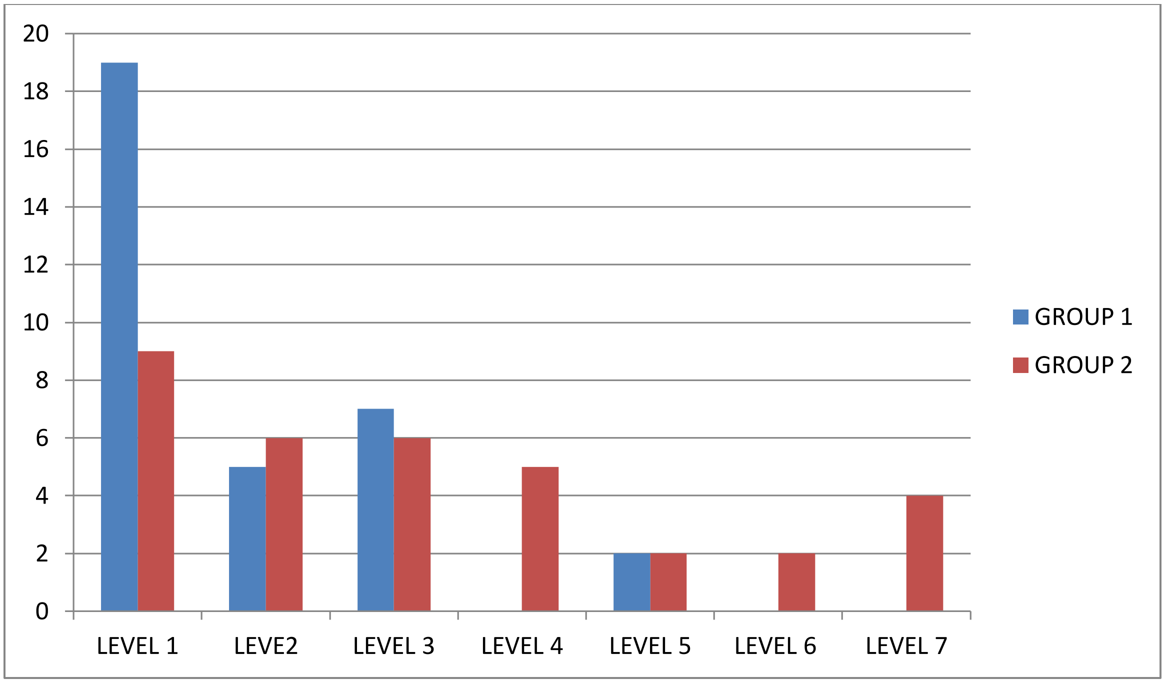


Figure 4.2: Level of scores for the post-test for Groups 1 and 2

The number of learners who achieved level 1 (30% and below) in Group 1 are more than the learners in Group 2. In Group 1, not one learner who scored 70% and above, and in Group 2, 6 learners scored above 70%. This implies that incorporating English language teaching in the science class has a positive effect on academic achievement. Jordan and Van Rooyen (2009) in Chapter 1 confirm that language competence and proficiency are central to educational success.

The tendency of leaving language to take care of itself has detrimental consequences. Science teachers need to be aware that language proficiency is as important as doing practical work in the science classroom. If issues of language are not resolved, how are learners going to communicate their findings in experiments? The tables below show the performance of learners in terms of questions or items. Item analysis looks into the performance of learners per question. It assist educators in finding out in which questions learners performed well and which questions were poorly answered.

Table 4.4: Item analysis for Group 1

Items	**Mean ***	**Number of learners with 40% and above**	**% of learners with 40% and above***
QUESTION 1	36.50	20	58.82
QUESTION 2	38.21	23	67.65
QUESTION 3	16.83	3	8.82

Table 4.5: Item analysis for Group 2

Items	**Mean ***	**Number of learners with 40% and above**	**% of learners with 40% and above***
QUESTION 1	68.82	30	88.23
QUESTION 2	47.69	26	76.47
QUESTION 3	34.28	14	41.18

The questions were itemised so that comparisons in terms of vocabulary and comprehension ability could be made. Question 1 dealt with one word items where learners were given a definition and had to give one word for the definition. Question 2 was multiple choice questions and Question 3 was open- ended questions dealing with calculations, and interpreting and describing motion from a graph.

The tables indicate that the mean percentages for Question 1 were 36.50% and 62.82% for Group 1 and Group 2 respectively. Question 1 dealt with recall and comprehension of scientific terms. The results indicate that the vocabulary and comprehension skills for Group 2 were better than for Group 1. This implies that the Group 2 learners were more familiar with words in Physical sciences than Group 1 indicating that they were more scientifically literate than Group 1.

In the lessons which incorporated language teaching and Physical Sciences, the learners were given English activities to complete. Madileng (2007) in section 2.6 concurs that reading skills are extremely important for academic development and that a skilful reader who possesses both receptive and productive skills of language use can acquire a higher level of comprehension and higher order skills which are very important for academic success. This was confirmed by the results. Engaging learners in reading can enable them to reach the independent level of reading where they can read science academic material with 98% decoding accuracy and at least 90% comprehension. The results are summarised in the chart below:

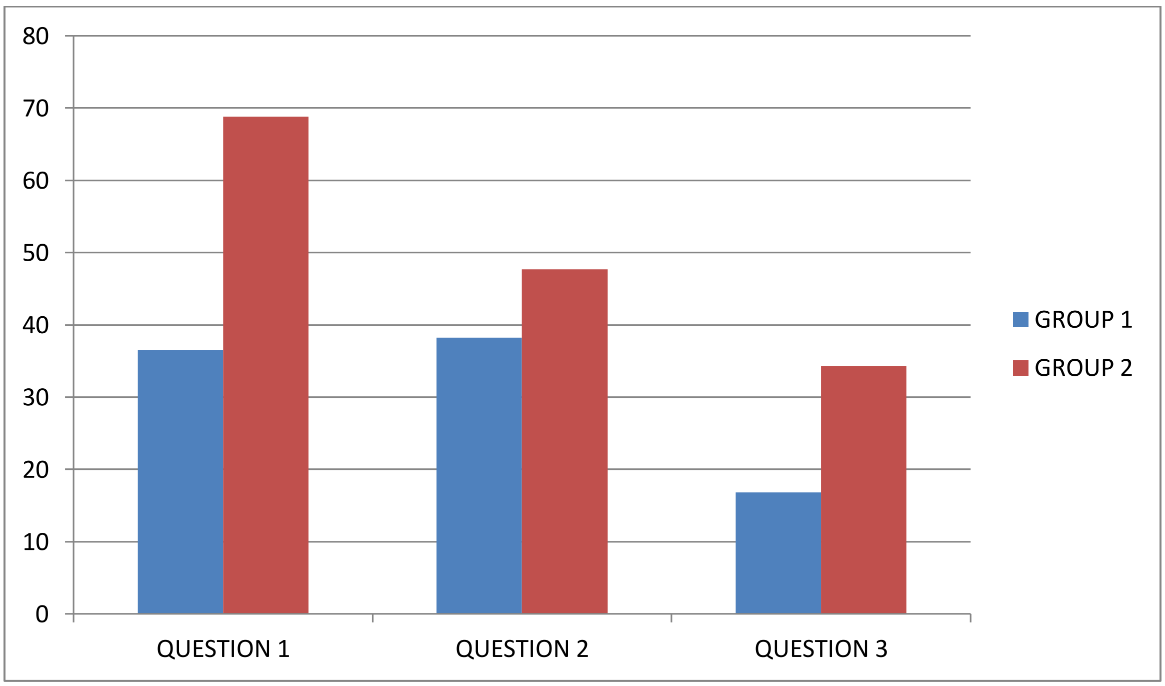


Figure 4.3: Comparison of item analysis mean percentages for Groups 1 and 2

The figure indicates that Group 1 learners were outperformed in all of the questions. The question which was poorly answered is Question 3. This is because most of the questions asked here were on cognitive levels 3 and 4. They dealt with application and scientific inquiry. However Group 2 managed to do well in these questions which require higher order thinking on the part of the learner and are cognitively demanding.

4.6 SUMMARY

In this chapter, the results acquired from the videos, the focus group interview, individual interviews, and the pre- and post-tests were classified, analysed, interpreted, and discussed. The results indicated that language lessons can indeed not be ignored in the teaching of science. The next chapter presents the conclusions and recommendations.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter briefly summarises the study and its main findings and then discusses the contribution which incorporating English language lessons in Physical Sciences can make in the science classroom. This is done under the following headings:

- Importance of incorporating English language teaching in sciences education.
- The importance of reading in science classrooms.
- Recommendations.
- Suggestion for further research.

5.2 SUMMARY OF THE FINDINGS

This section summarises the main conclusions of the study. This is done by initially discussing the importance of incorporating language teaching in science education. Lastly the importance of reading in science classrooms also is discussed.

5.2.1 THE IMPORTANCE OF INCORPORATING LANGUAGE TEACHING IN SCIENCE EDUCATION

The findings of the study proved beyond doubt that language lessons in science education is important and that language is one of the major barriers in the learning of science. This was confirmed in a focus group interview where learners stated that language was one of the major factors for poor performance in Physical Science. In section 2.7 it was also confirmed that one of the factors that contribute to high failure rates in mathematics and science is the language of teaching and learning (LoTL).

The report from the task team appointed by the minister of Basic Education also proved undisputedly that language is one of the major problem areas in the South African education system. The fact is that we are stuck with English as the language of teaching and learning and for the majority of learners in South Africa English is a second language. It is very important to acknowledge the importance of our home languages, especially African languages, which were marginalised during the apartheid regime. However it is equally important for learners to be competent in the LoTL. Therefore there is a need to implement strategies that will develop the LoLT as most learners still prefer English as the LoLT.

Something has to be done to narrow the language gap that most learners have and this can be done by incorporating English language teaching in science classroom. Despite English being the second language for most learners in South Africa, learning Physical Sciences is like learning a new language. This was confirmed by the literature review in Chapter 2 about the nature of scientific language which is characterised by its own technical terms that are not found in learners' daily lives.

The fact is that if language is a major barrier in the learning of science, science teachers need to do something to narrow the language gap. The findings of the study proved that by incorporating language strategies in science classrooms, academic results can be improved. The videos of lessons that incorporated English language teaching in science content teaching showed that it had many positive effects on the learners.

In these lessons various teaching approaches were employed and the methods were more learner-centred than the lessons which did not incorporate language teaching into science lessons. The methods were linked to constructivist theories of learning which assert that learning is an active process. One of the language teaching approaches that were incorporated in Physical Sciences lessons was the text-base or comprehension based method. This means that learners were given the opportunity to engage with the science text and actively construct their knowledge. It was characterised by silent moments during which learners completed the English tasks was based on the text. After completing the tasks, most learners were more familiar with the terms than the learners who did not engage with the text in a similar way.

The important thing is that the learners were encountering these words for the first time and understood that a scalar quantity is a physical quantity with magnitude only. The educator did not teach them these concepts; they discovered them for themselves from reading the text.

The findings of the study also discovered that if English language lessons are incorporated in Physical Sciences lessons learners' comprehension and vocabulary skills improve. The item analysis done on the post-test proved that the learners in the experimental lessons were able to recall most of the words that were asked in the one word items which did not hold true for their counterparts which means that they were scientifically more literate.

The results further indicated beyond doubt that the academic performance in lessons that incorporated language and science was better than in the other class. One of the issues in Physical sciences is that if learners do not understand the concepts it is very difficult to understand most of their applications in physics. For example, to understand the concepts of Newton Second law, the learners need to understand the relationship between acceleration and resultant force as well as the relationship between acceleration and mass. If learners do not understand these concepts well it will be difficult to apply them in daily life. Incorporating language lessons in science teaching assists in narrowing this gap. Every science lesson must include a language lesson.

Language is a major barrier in science learning because one of the important features of science is the richness of the words and terms it uses. Moreover almost all teaching and learning involves the medium of language and if the language is not understood learning cannot take place.

Although learners can use scientific terms in writing and speech it does not mean they understand them. Many of the words of science are complete strangers to learners and many of them struggle because they cannot interpret the meanings in question papers. To overcome these problem teachers need to incorporate language lessons in science classrooms. This cannot be done only by explaining the meaning of concepts; learners need to be actively engaged in tasks that can improve their comprehension skills in the subject.

Recently there has been a debate about the literacy rates of grade 12 learners who are entering university education. University world news (2009: 1) report that in 2009, HESA chairman, Professor Theuns Eloff, told parliament's higher education committee that most first-year students could not adequately read, write or comprehend, universities that conduct regular competency tests have reported a decline in standards. While undergraduate enrolments had been growing by about 5% a year, and black students now comprised 63% of enrolment, there was concern about high dropout (around 50%) and low graduation rates, especially among black students. Only a third of students obtain their degrees within five years. HESA's findings from the benchmark project make it clear that South Africa's school system is continuing to fail its pupils and the country, and that universities will need to do a lot more to tackle what appear to be growing proficiency gaps.

The issue of academic literacy cannot be left solely in the hands of universities, these problems emanates from the schooling system. The study suggests that improving academic literacy can be achieved if subjects educators are involved, especially Physical sciences educators as this is one of the most failed subjects in grade 12. It is clear that the current English curriculum is not assisting our learners in improving their academic literacy levels, as they still continue to perform poorly despite qualifying for university entry.

5.2.2 THE IMPORTANCE OF READING IN SCIENCE CLASSROOM

The importance of reading in science education and education in general cannot be underestimated. Although concerted efforts have been made to turn South Africa into a reading nation, there has never been much improvement. The introduction of the Annual National Assessment (ANA) where learners are writing standardised tests in language and mathematics in some grades is an indication of how literacy and numeracy are taken seriously in our education system.

The findings of the study indicate that it is not enough to ask learners to read a textbook in class. Science teachers must design activities that will engage learners in silent reading. In other words reading tasks must be structured so that they ask silent questions that address concepts in science. In the lessons that incorporated language lessons in science classes, the learners were given more time to read than their counterparts.

This is supported by Wellington and Osborne (2001: 41) who assert that:

> …reading is often a neglected activity in science classroom. Textbook are often used to provide homework. Traditionally science teachers have had little concern for text, this is unfortunate because practicing scientists spend a lot of time reading, much science can be learned more from reading than from observing or listening .Reading is an important but uncommon activity in science education and that one of the responsibilities of science teachers is to teach learners to read actively, critically and efficiently.

The implication is that reading as an activity cannot be an underestimated. Most of the learners who do not make it in science are probably those who struggle to read on their own. When learners are assessed in tests they are expected to read and interpret the set questions. Sometimes they fail because they are unable to interpret the questions. Madileng in section 2.4 concurs that reading skills are extremely important for academic development and therefore a skilful reader, who possesses both receptive and productive aspects of language use, can acquire a higher level of comprehension and higher order skills which are very important for academic success.

The findings of the study prove that the academic performance of learners in lessons that incorporated language teaching in science lessons was better than in the lessons that did not. One of the main reasons is that learners were given more reading time and this translated into improved academic performance. Teachers often complain that learners do not read but most learners do not have the necessary skills to engage in reading in the domain of science. Reading science text is not like reading a newspaper, therefore these skills must be taught by science teachers and not mainstream English teachers. As science teachers we need to engage learners in active reading guided by tasks rather than asking learners to simply read a textbook.

5.3 RECOMMENDATIONS

Based on the findings in this study recommendations are made to different stake holders in education. The study discusses recommendations to the Department of Basic Education, to publishers, and lastly to science teachers.

5.3.1 RECOMMENDATION TO THE DEPARTMENT OF BASIC EDUCATION

Something needs to be done to remedy the situation that the country faces with regards to Physical Sciences education in schools. Recently the minister of Basic Education Mrs Angie Motshega established a task team to deal specifically with Mathematics and Physical sciences challenges which indicates acknowledgment that there is a problem.

One of the contributing factors for the high failure rate in Physical Sciences is the language of teaching and learning. The Department needs to implement methods that address the language gap in Physical sciences. The following are possible solutions:

- Introducing a new subject in FET called English for Science Learners which replaces the English First Additional Language. In this subject learners will learn English in the context of science. The articles and materials will be science-related to help improve their scientific literacy. It does not help learners to pass English First Additional Language well but still perform poorly in Physical Sciences. It is much better if they learn English in the context of science.

- Increasing the instructional time for Physical Sciences. This need was also voiced by learners in the focus group interview. The table below illustrates the allocated instructional time in Grade 10-12 adapted from DBE (2011: 7).

Table 5.1: Allocated instructional time per week in FET

Subject	**Time allocated per week (hours)**
Home language	4.5
First Additional Language	4.5
Mathematics	4.5
Life orientation	2
A minimum of any three subjects	12 (3 x 4h)
Total	27.5

The table indicates that Physical Sciences is allocated 4 hours instructional time per week which can be increased to 4.5 hours which can be taken from the First Additional Language. This increased time can be devoted to improving the language of science. This means that the time will have increased by 30 minutes per week and if calculated over 40 weeks this will result in 20 hours per year devoted to the language of science. Physical Sciences educators will be expected to use this time to engage learners on how read and write in the Physical Sciences context. Textbooks will be adapted to incorporate language lessons in the Physical sciences textbook especially at the beginning of each topic. Teachers training institutions will also be expected to include the language of science in their curricula to assist teachers in narrowing the language gap in science education.

- The Annual National Assessment (ANA) should be implemented from grade R to grade 11, rather than in selected grades. This will assist in identifying if there are problems, especially on the literacy rates our learners. In FET, ANA should focus on CALP skills rather than on BICS. In this way, we will be able to identify if our learners are able to cope with the demands of English language as LOLT, especially for academic purpose.

5.3.2 RECOMMENDATIONS TO SCIENCES EDUCATORS

Physical Sciences educators must do away with the notion that language in the Physical Sciences classroom will automatically take care of itself. Educators have the responsibility of narrowing the language gap in the subject by designing language activities in science classrooms. Incorporating language strategies in science classrooms will assist learners in understanding the concepts better. Science educators must work with English First Additional Language educators during the reading and comprehension period to expose learners to science articles rather than articles which are not related to their field of specialisation.

5.3.3 RECOMMENDATIONS TO PUBLISHERS

Physical Sciences textbook writers must also be aware that they have a responsibility of narrowing the language gap in Physical Sciences. This can be done by including language activities in each unit or topic. The language activities must be completed by learners before new topics are is introduced. The activities will assist in orientating learners to the topic by engaging them in science reading. In the new CAPS textbooks there has been an improvement because definitions of new words are written in bold. However that is not enough; designing activities that addresses language issues are also needed to encourage learners to read the textbook. Most learners are not motivated to read unless reading is accompanied by an activity.

5.4 SUGGESTION FOR FURTHER RESEARCH

This study focused on incorporating language lessons in science classrooms and the focus was on reading and comprehension. However there are still more aspects of language in science classrooms that were not discussed in the study. One of the aspects is writing. Most of our learners still experience problems in putting words into writing. For example, many learners perform poorly in questions that ask them to explain or give reasons. The learners may know the reasons but have difficulty in putting them into writing. This is an aspect that needs to be thoroughly researched.

Another aspect of language is visual literacy. Most of the question papers in physics contain diagrams that learners have to interpret before they can answer the questions. If they are unable to interpret the diagrams they may not be able to answer the questions. Sometimes they are also expected to read values from graphs to use in performing calculations. Most learners still experience problems with interpreting such diagrams and it is suggested that these aspects be investigated.

Another aspect of language is talking in the science classroom. Most the learners are unable to talk in the science classroom because they are unable to express themselves well in the language of science. This was discovered during the focus group interview where some learners even chose to use their mother tongue in answering questions in the interview guide. This is an indication that communication in science classrooms is still a problem because of the language disparities that learners have. This aspect of language also needs to be researched.

5.5 SUMMARY

The aim of this study was to investigate the effects of incorporating language lessons in science education. The study undisputedly proved that many positive effects result from such an intervention. One of the effects is improving academic performance. It was also discovered that if language lesson are incorporated in science classrooms learners are able to comprehend the science concepts and talk about them. In addition lessons that incorporate language and science are more learner-centred and learners construct their own knowledge by engaging with the text.

Incorporating language lessons in science classrooms is not only important for academic success; it is the very process by which learners can be taught how to learn. The findings of this study revealed that paying attention to language in science education is one of the most important things to improve the quality of Physical Sciences education in our country. It is only once learners are able to apply and evaluate Physical Sciences concepts that they can acquire knowledge. This can be done by developing their comprehension skills in the science classroom.

In the meantime it is imperative that the stakeholders in our education system realise the urgency for something to be done to assist our learners in developing the language skills necessary for science learning. Education is allocated a big chunk of the budged each year as compared to other portfolios in South Africa. However research and media debates indicate that our education system is one of the poorest compared to other developing countries, and yet the most expensive after twenty years of democracy. This was also confirmed by the recent ANA results.

The fact is that even though South Africa is a multilingual society English remains the language of teaching and learning for the majority of the learners. Yet nothing is done to improve the status of English education, especially in assisting learners to develop CALP skills. The challenge is that science educators need to take matters into their own hands by incorporating language into their everyday teaching.

REFERENCES

Aebersold, J. and Field, M. 1997. *From reader to reading teacher*. New York: Cambridge University Press.

Anstrom, K., Lynch, S. and Dicerbo, P. (Ed.s). 1998. *Preparing secondary education teachers to work with English language learners: Science*. NCBE Resource Collection Series No. 11, December 1998. Available: http://www.ncbe.gwu.edu/necbepubs/resource/ells/science.htm accessed on 09/02/2012)

Bennett, C.I. 2007. *Comprehensive multicultural education. Theory and practice*. Sixth edition. United States: Pearson, Allyn and Bacon.

Best, R.M., Rowe, M., Ozuru, Y. and McNamara, DS. 2005. *Deep-level comprehension of Science texts: The role of the reader and the text*. *Topics in Language Disorders* **25**(1), 65.

Boscolo, P. and Mason, L. 2003. *Topic knowledge, text coherence, and interest: How they interact in learning from instructional texts*. The Journal of Experimental Education **71**(2), 126–148.

Borg, W.R. and Gall, M.D.1989.*Educational Research*. New York: Longman.

Broster, P., Horn, W., James, H. and Paarman, S. 2011. *Oxford Successful Physical Sciences (2nd ed): Learners Book.* South Africa. Oxford University Press.

Broster, P. and James, H. 2005. *Oxford Successful Physical Sciences Learner's Book.* Cape Town: Oxford University Press Southern Africa.

Broer, N. A., Aarnoutse, C. A. J., Kieviet, F. K. and Leeuwe, J. F. J. V. 2002. The effect of instructing the structural aspect of text, *Educational Studies* **28**(3), 213–238.

Clark, R. E. and Salomon, G. 2001.*Why should we expect media to teach anyone anything?*, *in* R. E. Clark (ed.), *Learning with Media*, Information Age Publishing, Connecticut, Chapter 3, pp. 37–70.

Coleman, M.F. 2003. *Promoting Reading comprehension among English second language high school learners in disadvantaged community*. Pretoria: University of South Africa.

Cresswell, J.W.1994.*Research Design: Qualitative and quantitative approaches*. Thousand Oaks: Sage.

Cummins, J. 2000. Language, Power and Pedagogy: Bilingual Children in the Crossfire. Clevedon, UK: Bilingual Matters.

Denzin, N. K., Lincoln Y.S. (eds). 2000. *Handbook of qualitative research*. 2nd ed. California: Sage.

Department of Basic Education (DBE). 2009. *Report of the Task Team for the review of the implementation of the National Curriculum Statement: presented to Ms Angie Motshega*. Pretoria: Department of Basic Education.

Department of Basic Education (DBE). 2010. *News Letter on the review of the implementation of the National Curriculum Statement, May 2010.* Pretoria: Department of Basic Education.

Department of Basic Education (DBE). 2010. *The Status of the Language of Learning and Teaching (LOLT) in South Africa: A quantitative overview*. Pretoria: Department of Basic Education.

Department of Basic Education (DBE). 2010. *Report on National Senior Certificate Results* Pretoria: Department of Basic Education.

Department of Education (DOE). 2003. *National Curriculum Statement Grade 10-12 (General) Physical Sciences.* Pretoria: Department of Education.

Department of Education (DOE). 2003. *National Curriculum Statement Grade 10-12 (General) First Additional languages.* Pretoria: Department of Education.

Department of Basic Education (DBE). 2011. *Curriculum and Assessment Policy Statement (CAPS) Grade 10-12 Physical Sciences.* Pretoria: Department of Basic Education.

Department of Basic Education (DBE). 2012. *National Senior Certificate: School subject report.* Pretoria: Department of basic education.

Downs, C. T. 2006. What should make up a final mark for a course? An investigation into the academic performance of first year Bioscience students. A*sessment and Evaluation in Higher Education*, 31: 345 – 364.

Eaves, S and Erford, B. 2009. *Item analysis*. The Gale group. Available: http://www.education.com (accessed on 12/06/2012).

Fang, Z. 2006. *The language demands of science reading in middle school*. *International journal of science education*. 28(5). April: 491-520.

Farrell, M.P and Ventura, F. 2010. *Words and Understanding in Physics. England: Routledge* Publishers. Available at: http://www.informaworld.com/smpp/title~content=t794297816 (accessed on 22/10/2011).

Ford, A. and Peat, F.D. 1998. *The role of language in science. Foundations of Physics.* Vol18, 1223. Available at: http://www.fdavidpeat.com/bibliography/essays/text/language.txt (accessed on 14/11/2012).

Fry, E. 2002. *Readability versus leveling*, *The Reading Teacher* **56**(3), 286–291.

Furtak, E. M. 2006.*The problem with answers: An exploration of guided scientific inquiry teaching*. *Science Education* **90**, 453–467.

Gardner, D. 2007. *Research about the Children's Immediate Understanding of Vocabulary*: *Contexts and Dictionary Definitions*. *Reading Psychology, 28,* 331-373.

Granville, S. 2001. *Comprehension or Comprehending. Using critical language awareness and interactive reading theory to teach learners to interact with text*. South African Linguistic and Applied language studies 19:13-21.

Halloun, I. A. 2007.*Mediated modeling in Science education*, *Science & Education* **16**, 653–697.

Henning, E.; van Rensburg, W. And Smit, B. 2004. *Finding your way in Qualitative Research.* Hatfield, Pretoria: Van Schaik.

Hesse-Biber, MN. & Leavy, P. 2004. *Approaches to qualitative Research: A reader on theory and practic*e. Inc. New York: Oxford University Press.

Holliday, W. G. 2003. *Influential research in Science teaching*: 1963–present, *Journal of Research in Science Teaching* **40** (Supplement), v–x.

Holliday, W. G., Yore, L. D. and Alvermann, D. E. 1994. *The reading-science learning-writing connection: Breakthroughs, barriers, and promises*, *Journal of Research in Science Teaching* **31**(9), 877–893.

Howie, SJ .2001. *Mathematics and Science Performance in Grade 8 in South Africa 1998/1999*. Pretoria: Human Sciences Research Council.

Human Sciences Research Council of South Africa. 2002. available at: http://www.hsrc.ac.za/research/timss/05.htm (accessed on 20/12/2011).

Hsu, P.L. and Yang, W.G. 2007. *Print and image integration of Science texts and reading comprehension: A systematic function linguistics perspective*, *International Journal of Science and Mathematics Education* **5**, 639–659.

Joppe, M. 2000. *The Research Process.* Available at: http://www.ryearson.co/~mjoppe/rp.htm (accessed on 01/07/2011).

Iding, M. K. 2000, Can strategies facilitate learning from illustrated Science texts?, *International Journal of Instructional Media* **27**(3), 289–301.

Johansson, R. 2003. *A key note speech at the International Conference "Methodologies in Housing Research" organised by the Royal Institute of Technology in cooperation with the International Association of People–Environment Studies, Stockholm*, 22–24 September 2003. Available at:

http://www.psyking.net/HTMLobj-3839/Case_Study_Methodology-_Rolf_Johansson_ver_2.pdf (accessed on 24/01/2014).

Jordan, H & Van Rooyen, D. 2009. *An Aspect of Language for Academic Purposes in Secondary Education: Complex sentence comprehension by learners in an Integrated Gauteng Schools.* Oxford: Blackwell.

Junius, R. 2009. *Factors affecting the teaching of English reading in a Second Language of grade 3 learners.* M.ED dissertation, University of South Africa, Pretoria.

Kendeou, P. and Van den Broek, P. 2005. *The effects of misconceptions on comprehension of scientific text*, *Journal of Educational Psychology* **97**(2), 235–245.

Kim, T.L.S. and Wai, M.C. 2007. *Language development strategies for the teaching of science in English*. Malaysia: Institute of Teacher Education Malaysia. Available http://www.recsam.edu.my.

Kintsch,W. and Kintsch, E. 2005. Comprehension, *in* S. G. Paris and S. A. Stahl (eds), *Children's Reading Comprehension and Assessment*, Lawrence Erlbaum Associates, Mahwah, New Jersey, pp. 71–92.

Klassen, S. 2006. A theoretical framework for contextual Science teaching, *Interchange* **37**(1–2), 31–62.

Kober, N. [Sa]. *What special problems do LEP students face in science? What can teachers and schools do? Available* at: http://www.enc.org/topics/equity/articles/document.shtm?input=ENC-111335-1335 (accessed on 15/08/2012).

Krupp, K.L. 2009. *What impact of teaching vocabulary and comprehension strategies in seventh grade science have on High stake test scores*. Ohio: Bowling Green State University.

Kumar, R. 2002. *Research methodology: a step-by-step guide for beginners*. 2nd ed. London: Sage.

Leedy, P. and Ormrod, J.E. 2005. *Practical Research Planning and Design.* Saddle River, New Jersey: Pearson Education.

Lillywhite, K.M. 2011. Developing cognitive academic skills (CALP) in diverse classroom. Undergraduate Honours Thesis: Utah State University.

Logan, P. & Hazel, E. 1999. Language background and assessment in Physical Sciences. *Assessment and Evaluation in Higher Education*, 24: 53 – 65.

Madileng, M.M. 2007*. English as a medium of instruction: the relationship between motivation and English second language profici*ency. PHD thesis, University of South Africa, Pretoria.

Mayer, R. E. 2003. The promise of multimedia learning: Using the same instructional design methods across different media, *Learning and Instruction* **13**, 125–139.

McMillan , J.H., and Schumacher, S. 2010. *Research in education: Evidence based inquiry.* New Jersey: Pearson.

McNamara, D. S., Kintsch, E., Songer, N. B. and Kintsch, W. 1996. *Are good texts always better? Interactions of text coherence, background knowledge, and levels of understanding in learning from text*, *Cognition and Instruction* **14**(1), 1–43.

Mikkil¨a-Erdmann, M. 2002. *Science learning through text: The effect of text design and text comprehension skills on conceptual change, in M. Lim´on and L. Mason (eds), Reconsidering Conceptual Change. Issues in Theory and Practice*, Kluwer Academic, Dordrecht, pp. 337–356.

Miller, L. 2002. Towards a model for lecturing in a second language. *Journal of English for Specific Purposes*, 1:145 – 162.

Mkandawire, M. 2009. *Physical science activities and skills development in the school curriculum of Namibia.* M.ED dissertation, University of South Africa, Pretoria.

Mouton, J. 2005. *How to Succeed in your Master's and Doctoral Studies. A South African guide and resource book.* Pretoria: Van Schaik.

Murphy, C., Beggs, J., Hickey, I., O'Meara, J. and Sweeney, J. 2001. National curriculum: Compulsory school Science – is it improving scientific literacy?, *Educational Research* **43**(2), 189–199.

Muzah, P. 2011. *An Exploration into the School Related Factors that Causes High matriculation Failure Rates in Physical Science in Public High School in Alexander Township*. M.ED dissertation, University of South Africa Pretoria.

Norris, S. P. and Phillips, L. M.[*Sa*]. *Reading as inquiry* [online]. Available at: http://www.ruf.rice.edu/~rgrandy/Norris.doc (accessed on 26/06/2011)

Olivier; A. *[Sa]. Physical Sciences Grade 10:Book 1.* Kroondal: Reivilo.

Osborne, J. 2002. *Science without literacy: A ship without a sail*?, *Cambridge Journal of Education* **32**(2), 203–218.

Otero, J. C. and Campanario, J. M.1999. *Comprehension evaluation and regulation in learning from Science texts, Journal of Research in Science Teaching* **27**(5), 447–460.

Oyoo, S. 2005. *Science teachers' awareness of the impact of their classroom language*. Australia: Monash University.

Philips, L M and Norris, SP. 2009. *Bridging the gap between the language of science and the language of school science through the use of adapted primary literature*. Canada: Springer Science +Business Media BV

Pillay, J. 2004. *Experiences of learners from informal settlements*. South African Journal of Education, 24 (1): 5-9.

Pretorius, E. J. 2006. *The comprehension of logical relations in expository texts by students who study through the medium of English second language*. *Science Direct*, 34: 432 – 450. doi:10.1016/j.physletb.2003.10.071[14 May 2010]

Probyn, MJ. 2005. *Learning science through two languages in South Africa. Proceedings of the 4th international symposium of bilingualism*. Eds. Cohen, J, Karet, TM, Rolstad, K & Macswan, j. 1855-1873. Somerville, MA: Cascadilla Press.

Prophet, R.B., and Badebe, N.B. 2006. *Language and Student Performance in Junior Secondary Science examinations: The Case of Second Language Learners in Botswana*. International Journal of Science and Mathematics Education. (2009)7:235-251.

Renner, M., and Taylor-Powell, E. [Sa]*Analyzing Qualitative Data: Program Development and Evaluation. Madison, Wisconsin: University of Wisconsin Extension.*

Richards, J.C., and Shea, KT. 2006. *Moving from Separate Subject to Interdisciplinary Teaching: the complexity of change in a pre-service teacher K-1 Early field experience. The qualitative report (11).* March: 1-19. available at: http://www.nova.edu/ssss/qr/qr11-1.richrdshea.pdf (accessed on 15/02/2012).

Scantlebury, K., Tal, T., and Rahm, J. 2007. "*That don't look like me." Stereotypic images of Science: Where do they come from and what can we do with them?*, *Cultural Studies of Science Education* **1**, 545–558.

Setati, M.C. 2011. *English as a Language of Learning and Teaching Science in Rural Secondary Schools: A Study of the Vlakfontein Circuit in Limpopo*. PHD thesis, University of South Africa, Pretoria.

Shaw, J. (2002). L*inguistically responsive Science Teaching. Electronic Magazine of Multicultural Education* Vol. 4, No. 1 Available at: http://www.eastern.edu/publications/emme (Accessed on 15/08/2011).

Shrunkink, W.2010. The Qualitative refresher course. Johannesburg: University of Johannesburg.

Simala, I.K. 2001. *African Linguistic Nationalism and the Discourse of Globalization*. Addis Ababa, Ethiopia: Organization for Social Science Research in Eastern and Southern Africa (OSSREA).

Stahl, S., Jacobson, M. G., Davis, C. E. and Davis, R. L. 2006. *Prior knowledge and difficult vocabulary in the comprehension of unfamiliar text*, *in* K. A. D. Sathl and M. C. McKenna (eds), *Reading Research at Work: Foundations of Effective Practice*, The Guildford Press, New York, pp. 284–302.

Street, B. & Hornberger, N.H (Eds). 2008. Encyclopedia of Language and Education, 2nd Edidtion, volume 2: Literacy. (PP.71-83). New York: Springer science + Business Media LLC.

Swanepoel, S. 2010. *The assessment of the quality of science education textbooks: Conceptual framework and instruments for analysis*. PHD thesis, University of South Africa, Pretoria.

Tenopir, C., & King D.W. 2004. *Communication patterns of engineers.* Hoboken, NY:Wiley.

Thiede, K. W., Anderson, M. C. M. and Thierriault, D.: 2003, *Accuracy of metacognitive monitoring affects learning of texts, Journal of Educational Psychology* **95**(1), 66–73.

Tingting, Q. 2011. *A Comparison between the Text-based Approach and the Dictionary-based Approach of Vocabulary Learning in a Chinese* University. Republic of China: Kristianstad University

Trends in International Mathematics and Science Study (TIMSS). 1999. Mathematics and Science Achievement of Eighth Graders in 1999. Available at: http://nces.ed.gov/about/ (accessed on 12/12/2011)

Trowbridge, LS, Bybee, RW & Powell, JC. 2004. *Teaching secondary school science.* Strategies for developing scientific literacy. Eighth edition. New Jersey: Pearson.

University world news. 2009.16 August.35. Available at:http://www.universityworldnews.com/article.php?story=20090816082047397

(Accessed on 18/08/2014)

Van Staden, V.A.E. 2010. *Exploring English second language speakers' scientific writing skills strategies in first year life sciences. M.ED dissertation,* University of South Africa, Pretoria.

Vekiri, I.: 2002, What is the value of graphical displays in learning?, *Educational Psychology Review* **14**(3), 261–312.

Vine, E. W. 1997. *Language across the curriculum: The language learning potential in a science text*. (ERIC Document Reproduction Service No. 424 763)

Walsh, M.: 2006, *The 'textual shift': Examining the reading process with print, visual and multimodal texts, Australian Journal of Language and Literacy* **29**(1), 24–37.*Psychology Review* **14**(3), 261–312. [online]. Available from: http://www2.educ.sfu.ca/narstsite/publications/research/textbook2.htm (Accessed on 24/09/2011)

Willemse, L. 2005*. Effects of Promoting Comprehension skills among First year University students*. MA dissertation, University of South Africa, Pretoria.

Wellington, J. and Osborne J. 2001. *Language and literacy in science education*. Buckingham: Open University Press.

Winegardener, K.E. 2001. The Case Study Method of Scholarly Research. The Graduate School of America. Accessed on 17 March 2010 from: http://www.tgsa.edu/online/cybrary/casel.html (accessed on 13/01/2012)

Wisker, G. 2001. The Postgraduate Research Handbook. New York: Palgrave.

Woolfolk, A. 2007. *Educational psychology*. Tenth Edition. Boston: Pearson

Yore, LD, Shymansky, JA, Henriques, L, Chidsey, JL, and Lewis JO. Sine anno. *Reading-to-learn and writing-to-learn science activities for the elementary school classroom*. USA: University of Victoria, University of Lowa, California State University.

APPENDIX 1 (Letter to DOE)

P.O BOX 206

KWAMHLANGA

1022

6 August 2013

To: Circuit Manager/Regional Director

Mpumalanga Department of Education

Nkangala region

Private Bag x 4021

KwaMhlanga

1022

Dear Madam/Sir

Permission to conduct research at Silamba secondary School

As a staff member of the above mentioned school and a Masters student at the University of South Africa, I hereby ask permission to conduct research at Silamba Secondary School. I am conducting a study for my dissertation. The title for the dissertation is "Exploring effects of incorporating English language teaching in physical sciences classrooms: A case of secondary physical sciences education in Mpumalanga Province". In the third term, our next module will be on mechanics. While the learner seem to be excited about the topic, the curriculum is difficult. My study should enhance their learning experience. I will be using reading and comprehension strategies throughout the module in one classroom while in the other classroom teaching will continue as usual. None of the learners' physical sciences content will be compromised. I will be looking at a variety of ways to teach the learners to better read, understand, and in turn, answer questions. At the beginning of the unit, learners will take a pre-test on the topic of mechanics. We will not go over this test, I will simply examine and record the data; the learners' names will not appear on any of the materials released but numbers will be assigned. We will then continue with science classes as usual. However, I will be embedding reading and comprehension strategies right into their daily lessons in one class which will be the experimental group. We will work our way through the mechanics chapter using these strategies. At the end of the chapter, I will give the students the same test they previously took. My goal is that as we work through our current module, focusing on reading and comprehension of the questions, to improve the learners' marks by teaching them how to answer the questions. My intention is to improve their ability to show what they know, by understanding what the questions are asking. Permission will be requested from the principal, teachers, parents, and learners. The participation of learners in the study will be voluntary and they are free to withdraw from participation in the study at any point should they so wish.

Thanking you in advance

Regards Date

15 May 2013

Mr. Hlabane AS

APPENDIX 2 (Letter to the Principal)

P.O BOX 206

KWAMHLANGA

1022

6 August 2013

To: Principal

Silamba Secondary School

P O BOX x 689

KwaMhlanga

1022

Dear Madam/Sir

Permission to conduct research at Silamba secondary School

As a staff member of the above mentioned school and the Masters student at University of South Africa; I hereby ask permission to conduct research at Silamba Secondary School. I am conducting a study for my dissertation. The title for my dissertation is “Exploring effects of incorporating English language in Physical Sciences classroom: A case of secondary physical sciences education in Mpumalanga Province”. In the third term, our next module will be on mechanics. While the learner seem to be excited about the topic, the curriculum is difficult. My study should enhance their learning experience. I will be using reading and comprehension strategies throughout the module in one classroom while in the other classroom teaching will continue as usual. None of the learners’ physical sciences content will be compromised. I will be looking at a variety of ways to teach the learners to better read; understand and in turn, answer questions. At the beginning of the unit, learners will take a pre-test over content on the topic of mechanics. We will not go over this test, I will simply examine and record the data, learner’s name will not appear on any of the materials released, and a number will be assigned. We will then continue with science class as usual. However, I will be embedding reading and comprehension strategies right in their daily lessons in one of the class which will be the experimental group. We will work our way through the mechanics chapter using these strategies. At the end of the chapter, I will give the students the same test they previously took. My goal is that as we work through our current module, focusing on the reading and comprehension of the questions, the learner's mark will improve due to the material they had used , by learning how to answer the questions. My intention is to improve their ability to show what they know, by understanding what the questions are asking. Consent permission from the teachers of the classes; parents and learners will be requested. The participation of learners in the study is voluntary and learners are free to withdraw from participating in the study at the later stage of the study.

Thanking you in advance

Regards Date

15 May 2013

Mr. Hlabane AS

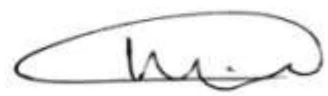
APPENDIX 3 (Letter to Parents)

Dear Parent/Guardians

I am a postgraduate student at the University Of South Africa. I am currently working on my masters of Education in Natural Sciences Education. I am conducting a study for my dissertation. My study will look at the effects of incorporating English language in Physical Sciences classroom. In the third term of 2013 academic year; our next module will be on mechanics. While the students seem to be excited about the topic, the curriculum is difficult. My study should enhance their learning experience. I will be using reading and comprehension strategies throughout the module in one of the grade 10 classes and in the other classes teaching will continue as normal. None of your child's Physical Sciences content will be compromised. I will be looking at a variety of ways to teach your child to better read, understand and in turn, answer questions. At the beginning of the unit, your child will take a pre-test over content of mechanics. We will not go over this test, I will simply examine and record the data, your child's name will not appear on any of the materials released, and a number will be assigned. We will then continue with science class as usual. However, I will be embedding reading and comprehension strategies right in their daily lessons for one class and in the other class teaching will continue as usual. We will work our way through the mechanics chapter using these strategies. At the end of the chapter, I will give the students the same test they previously took. My goal is that as we work through our current module, focusing on the reading and comprehension of the questions, the learner's mark will improve due to the material they had used , by learning how to answer the questions. My intention is to improve their ability to show what they know, by understanding what the questions are asking. All learners will participate in the regular classroom activities, however, if you do not wish for me to include their results you do not need to return the consent form. I am very excited about the findings as I truly believe that all learners are capable of improvement. All information obtained from this study will be kept confidential and learner's participation is voluntary. Learner's names will not be included in any of the material that I submit. I encourage you to review the progress taking place in the classroom. You can contact me or my University supervisor. If you have any questions regarding the study, please contact me at hlabaneas@gmail.com or my University supervisor Prof Nkopodi, University of South Africa, at nkopon@unisa.ac.za.

Thanking you in advance for your cooperation, and as always, I look forward to working with your child.

Regards Date



15 May 2013

Mr. Hlabane AS

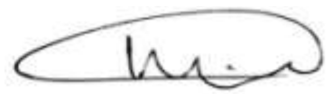
APPENDIX 4 (Letter to learners)

Dear Learners,

I am a post graduate student at the University of South Africa working on completing a Masters degree in Natural Science Education. At the beginning of the third quarter of 2013 academic year I will be collecting data regarding my study. I will be using reading and writing strategies in the physical science classroom in one classroom while in another class teaching will continue the way it used to be. Your participation in this study is voluntary, and you may choose later that you no longer want to participate. I will understand and respect your decision whether you choose to participate or not. I will not be upset with you if you choose not to participate. The way that work is done in the classroom will not change and you will not have any extra work by choosing to participate. At the beginning of the unit, you will take a pre-test over the content of mechanics. I am not going to give you the answers right after the test. Instead, we will continue with the mechanics module. You will take the same test again at the end of the module. There will be no new information on the test. This will hopefully just help you to better understand what the questions are asking. I will compare your marks to see if once we discussed the meanings of these words, you will have scored higher marks. At the end of the mechanics module, I will randomly select some of you to participate in the focused group interview. The interview will be on what we did during the module. All learners will complete this activity as a part of our classroom activities. However, your marks on the pre and post tests will not affect your classroom marks. You are not taking any risks by participating in this study. By signing the consent form you are allowing me to include your mark in my data. I will not use your name on any of the information that I use in my dissertation, I will replace your name with a number. All of your information will be kept confidential. This means that no one will be able to tell who received what marks. If you have any questions as we are working on this, please ask me. I would be glad to explain it to you.

Thank you all, I am looking forward to working with all of you.

Regards



Mr. Hlabane AS

Date

22 August2013

APPENDIX 5

(Letter to the teachers of the classes)

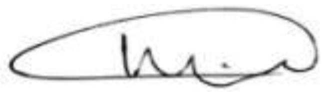
Dear Teachers

I am a postgraduate student at the University Of South Africa. I am currently working on my masters of Education in Natural Sciences Education. I am conducting a study for my dissertation. My study will look at the effects of incorporating English language in physical sciences classroom. In the third term of 2013 academic year I will be working with Grade 10A and 10B in collecting data for my study. One of the classes will be the experimental group while other class will be the control group. While the learners seem to be excited about the topic, the curriculum is difficult. My study should enhance their learning experience. I will be using reading and comprehension strategies throughout the module in the experimental group while in the other class teaching will continue as normal. None of the learners' Physical Sciences content will be compromised. I will be looking at a variety of ways to teach the learners to better read; understand and in turn, answer questions. At the beginning of the unit, learners will take a pre-test over content of mechanics. We will not go over these tests, I will simply examine and record the data, learner's name will not appear on any of the materials released, and a number will be assigned. We will then continue with science class as usual. However, I will be embedding reading and comprehension strategies right in their daily lessons for the experimental group. We will work our way through the mechanics chapter using these strategies. At the end of the chapter, I will give the Learners the same test they previously took. My goal is that as we work through our current module, focusing on the reading and comprehension of the questions, the learner's mark will improve due to the material they had used , by learning how to answer the questions. My intention is to improve their ability to show what they know, by understanding what the questions are asking. All learners will participate in the regular classroom activities. I am very excited about the findings as I truly believe that all learners are capable of improvement. All information obtained from this study will be kept confidential. Learner's names will not be included in any of the material that I submit. Their participation is voluntary and they are free to withdraw from the study at the later stage. I encourage you to review the progress taking place in the classroom. You can contact me or the University supervisor. If you have any questions regarding the study, please contact me at hlabaneas@gmail.com or my university supervisor Dr Nkopodi, University of South Africa, at nkopon@unisa.ac.za.

Thanking you in advance for your cooperation, and as always, I look forward to working with the learners in your class.

Mr. Hlabane AS

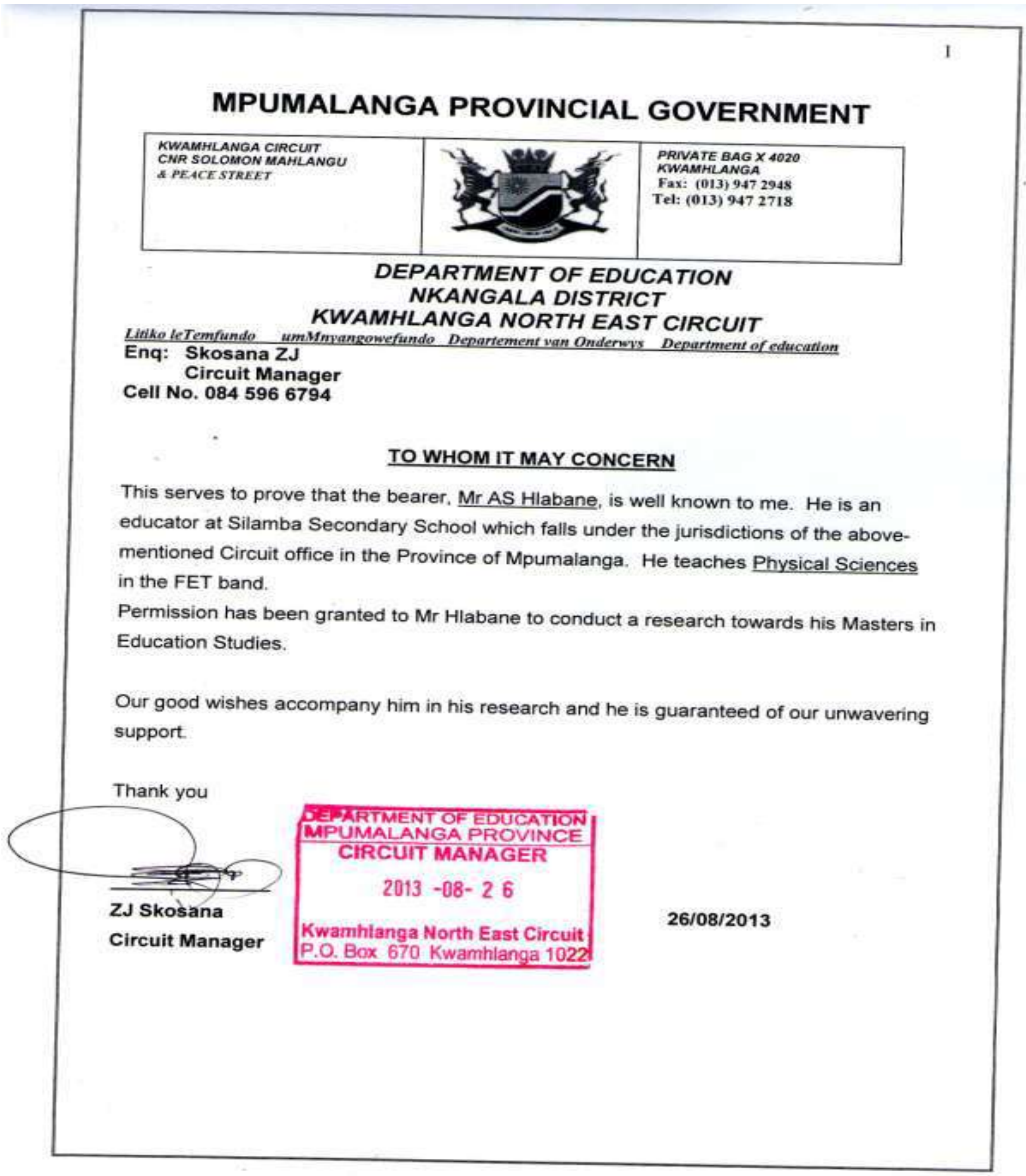
Regards   Date



15 May 2013

Mr. Hlabane AS

APPENDIX 6: Permission letter from DOE



I

MPUMALANGA PROVINCIAL GOVERNMENT

KWAMHLANGA CIRCUIT *CNR SOLOMON MAHLANGU* *& PEACE STREET*		*PRIVATE BAG X 4020* *KWAMHLANGA* Fax: (013) 947 2948 Tel: (013) 947 2718

DEPARTMENT OF EDUCATION
NKANGALA DISTRICT
KWAMHLANGA NORTH EAST CIRCUIT

Litiko leTemfundo umMnyangowefundo Departement van Onderwys Department of education

Enq: Skosana ZJ
Circuit Manager
Cell No. 084 596 6794

TO WHOM IT MAY CONCERN

This serves to prove that the bearer, Mr AS Hlabane, is well known to me. He is an educator at Silamba Secondary School which falls under the jurisdictions of the above-mentioned Circuit office in the Province of Mpumalanga. He teaches Physical Sciences in the FET band.

Permission has been granted to Mr Hlabane to conduct a research towards his Masters in Education Studies.

Our good wishes accompany him in his research and he is guaranteed of our unwavering support.

Thank you

DEPARTMENT OF EDUCATION
MPUMALANGA PROVINCE
CIRCUIT MANAGER
2013 -08- 2 6
Kwamhlanga North East Circuit
P.O. Box 670 Kwamhlanga 1022

ZJ Skosana
Circuit Manager

26/08/2013

APPENDIX 7 (Permission letter from the Principal)

SILAMBA SECONDARY SCHOOL

P.O. BOX 689 KWAMHLANGA 1022

EMIS: 800021097
ENQ: DR EN MABENA

TEL/FAX: 0139470774
EMAIL: silamba.ss.school@gmail.COM

To whom it may concern

This is to certify that Mr AS Hlabane is the staff member of the above mentioned school. He is teaching Physical sciences Grade 10 to 12. As the Principal of the school, I hereby certify that he has been granted permission to conduct research for his Master in Education with specialization in Natural Sciences Education for 2012 and 2013. I have read his research proposal and I have noticed that it will not disadvantage the learners in anyway. Instead the learners will benefit from his study. The study is about language in Science Education, most of our learners learn English as a second language and this study might remedy the problem we have with language problems. The circuit manager is also aware of his study and this is taken as staff development.

I hope you will find this in order.

Regards

Date

22/08/13

Dr Mabena EN (Principal)

APPENDIX 8

Parents consent form

I the parent/guardian to …………………………………………………(child’s name) consent to my child’s participation in “Exploring effects of incorporating English language Teaching in secondary school science education”. I am also aware that my child’s participation is voluntary and that my child may withdraw if he or she does not want to continue with the study. I understand that the findings of the study will be confidential and that my child’s name will not be included in the results instead a number will be assigned.

____________________________ ____________________________

Name of Parent or guardian Parent Signature

APPENDIX 9

Learner consent form

I ………………………………………………(Learner's name) consent to participation in "exploring effects of incorporating English language in secondary school science education". I am also aware that my participation is voluntary and that I may withdraw if I do not want to continue with the study. I understand that the findings of the study will be confidential and that my name will not be included in the results instead a number will be assigned.

_____________________________ _____________________________

Learner Signature Date

APPENDIX 10

Teachers consent form

I consent to the learners' participation in "exploring effects of incorporating English language in secondary school science education". I am also aware that learners' participation is voluntary and that they may withdraw if they do not want to continue with the study. I understand that the findings of the study will be confidential and that my learners name will not be included in the results instead a number will be assigned.

Name of Teacher

Teacher's Signature

APPENDIX 11

Focus group Interview guide

1. **Introductions**

The researcher will introduce himself and assure the participants that the information given will be strictly confidential and their names will not be mentioned in the report.

2. What makes Physical science difficult as a subject according to your view?
3. Do you think that language affects the pass rate in science?
4. What language would you prefer to study science with?
5. How are you taught reading in English classroom? What type of articles (e.g. newspapers) do you usually use when you learn your reading strategies? Do you sometimes read science articles in English classroom?
6. Do you think that incorporating language lessons (reading strategies in science classroom) can help you in understanding the subject better?
7. Do you think that physical sciences have distinct terms from other disciplines? Give examples.
8. How does the language used in physical sciences compare with language used in other disciplines? Give examples.
9. How best do you think physical sciences should be taught?

What else would you like to add?

APPENDIX 12

PHYSICAL SCIENCES PRE/POST-TEST

Grade 10

MARKS: 50

Duration: 1 hour

Instructions:

1. Write all questions.
2. A calculator may be used.
3. Use a pencil for drawings.
4. Write neatly and legibly.
5. You may use attached formula sheet where necessary.

SECTION A

QUESTION 1: ONE-WORD ITEMS

Give ONE word/term for EACH of the following descriptions. Write only the word/term next to the question number (1.1 – 1.5) in the ANSWER BOOK.

1.1	The rate of change of velocity.	(2)
1.2	Physical quantities with magnitude only.	(2)
1.3	The quantity that is represented by the area under the velocity-time graph	(2)
1.4	The rate at which distance is covered.	(2)
1.5	The vector quantity that has the same effect as two or more vector quantities.	(2)
		[10]

QUESTION 2: MULTIPLE-CHOICE QUESTIONS

Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Choose the answer and write only the letter (A – D) next to the question number (2.1 – 2.10) in the ANSWER BOOK.

2.1 Which ONE of the following quantities is NOT a vector quantity?

A Force

B Energy

C Displacement

D Acceleration (2)

2.2 Which ONE of the following quantities represents change in position of an object?

A Force

B Energy

C Displacement

D Acceleration (2)

2.3 The gradient of the displacement graph is represented by:

A Velocity

B Speed

C Time

D Distance (2)

2.4 Which of the following statements is CORRECT?

A Time is a vector quantity

B The SI unit for distance is kilometer

C Displacement is a vector quantity

D Acceleration is measured in meters. (2)

2.5 Which ONE of the following is the unit of measurement for the rate of change of displacement?

A $m.s^{-1}$

B seconds

C $m.s^{-2}$

D meters (2)

2.6 The difference between velocity and speed is that:

A Speed is a vector quantity and velocity is a scalar quantity

B Speed is measured in meters and velocity is measures in meters per second.

C Speed is a scalar quantity and velocity is a vector quantity

D Speed is measured in meters per second and velocity is measured in meters. (2)

2.7 Which of the following represents one dimension motion?

A A car moves east and later it turns and move in the northerly direction

B A car moves in a straight line and moves up a cliff and turn to the left

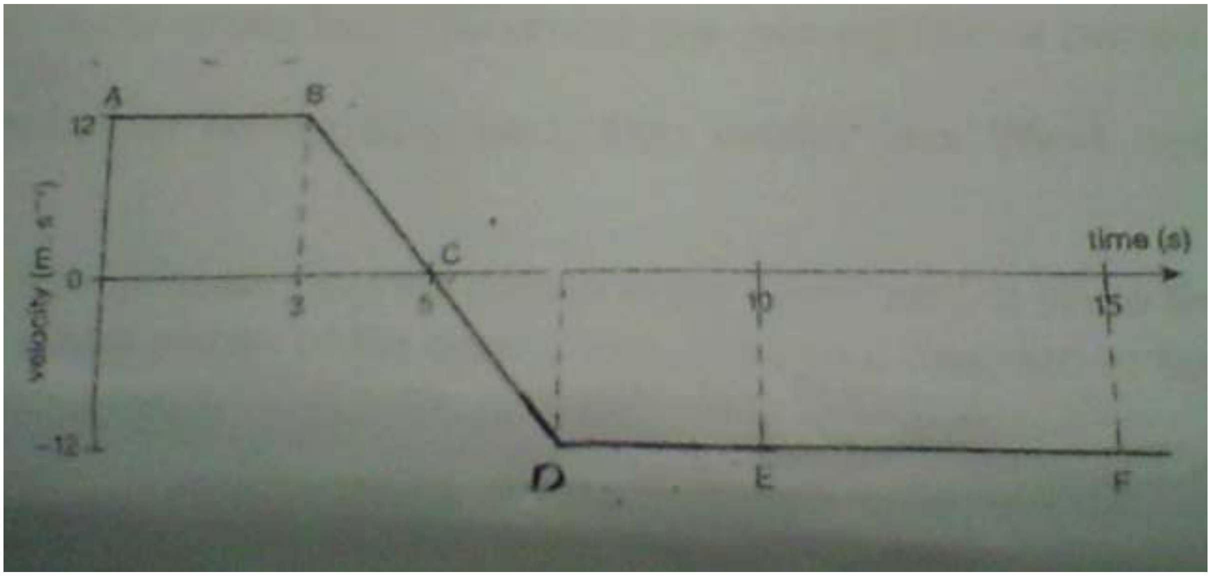
C A car moves in a straight line and turns and enter a parking lot

D A car moves forward in a straight line and later turns and move in opposite direction (2)

[14]

QUESTION 3

The velocity-time graph shown below represents the motion of a car in a straight line which initially moved in the



3.1	Describe the motion of the car in terms of acceleration and velocity at: a) AB b) BC c) C	 (3) (3) (3)
3.2	What is the acceleration of the car between A and B?	(2)
3.3	Calculate the acceleration of the car between B and C without using equations of motion.	(4)
3.4	Calculate the displacement of the car for the first 5 seconds (do not use equations of motion).	(6)
3.5	Hence, calculate the average velocity over the 5 seconds.	(2)
3.6	Which part(s) of the graph shows that the car moving in westerly direction? Give a reason for your answer.	(3)

[26]

TOTAL MARKS: 50

TABLE 1: FORMULAE

MOTION/*BEWEGING*

$v_f = v_i + a\Delta t$	$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$
$v_f^2 = v_i^2 + 2a\Delta x$	$\Delta x = \left(\frac{v_f + v_i}{2}\right)\Delta t$

Memorandum

Question 1

1.1 Acceleration √√

1.2 Scalar quantities√√

1.3 Displacement √√

1.4 Speed √√

1.5 Resultant √√

[2X5=10]

Question 2

2.1 B√√

2.2 C√√

2.3 A√√

2.4 C√√

2.5 A√√

2.6 C√√

2.7 D√√

[2X7=14]

QUESTION 3

3.1a) The car moves at constant velocity and zero acceleration. √√√

b) Velocity is decreasing while acceleration is constant. √√√

c) The car has stopped (zero velocity) - there is no acceleration. √√√

3.2 $0 m.s^{-2}$√√

3.3 m= $\Delta y/\Delta x$√

=0-12/5-3√√

a =$-6 m.s^{-2}$√√

3.4 Δx= area(AB) +area(BC) √

= (l x b) + (1/2b.h) √

=(12 x3) + (1/2x2x12) √√√

=48m√

3.5 V=$\Delta x/\Delta t$√

=48m/5s √

= $9,6 m.s^{-1}$√

APPENDIX 13

Workbook

Motion in one dimension

UNIT 1: VECTORS AND SCALARS

Physical quantities

A physical quantity is a measurable property of something that we find in nature.

Table 1 below gives some example of SI units of measurement of physical quantities and symbols that we use when we do calculations.

Physical quantity	Quantity symbol	SI unit of measurement	Unit symbol
Time	T	Second	s
Mass	*M*	Kilogram	Kg
Weight	**W**	Newton	N
Force	**F**	Newton	N
Charge	**Q**	Coulomb	C

There are two types of physical quantities:

Scalar quantities

Scalars are physical quantities that have magnitude (size) only.

Examples of scalars quantities are

mass, time, volume, energy, potential difference, distance

Vector quantities

Vectors are physical quantities that have both magnitude and direction.

In this book vector quantities are printed in bold. For example,

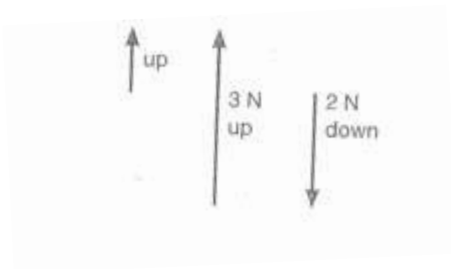
weight, force, charge velocity, displacement, acceleration

Negative scalars and vectors

A negative vector of a given vector has the same magnitude as a given vector but acts in opposite direction. The figure below shows force **F** acting towards the right. If the force is made to act in opposite direction it is the negative of **F** OR **–F**. It is still the same magnitude but only differ in direction. If you compare this with scalar quantities where a negative value often represents less, for example -10^{0}C IS less than 10^{0}C.

Graphical representation of vectors

A vector diagram is a graphical representation of vectors. We use a line with an arrowhead on one end to represent a vector graphically. The length of an arrow represents its magnitude. The figure below shows relative sizes and directions of two forces.



The Resultant

The **resultant** is the vector quantity that has the same effect as two or more vector quantities. The resultant is found by addition. The resultant for $\boldsymbol{F_1}$ and $\boldsymbol{F_2}$ can be written as a vector equation:

Resultant $\mathbf{F_R} = F_1 + F_2$

Activity 1E

1.1 Which word in the notes means a “measurable property of something we find in nature”?

1.2 Which of the following is not a physical quantity?

A Mass

B Energy

C Newton

D Distance

1.3 Which word in the notes is a synonym of size?

1.4 State whether the following statements are true or false:

i) A vector quantity is a physical quantity with magnitude only.

ii) A negative vector has the same magnitude as a given vector but acts in opposite direction.

iii) A negative vector means that it is less value than an equal opposite value.

(e.g. -4N is less than +4N).

1.5 What is the meaning of a vector diagram? (From question 1.5 to 1.7 circle the correct answer)

A numerical representation of vectors

B the length of an arrow

C graphical representation of a vector

1.6 A resultant is found by:

A multiplication

B addition

C subtraction

D division

1.7 The length of the arrow in representing vectors represents:

A direction of the vector

B magnitude of the vector

C the addition of vectors

ACTIVITY 1 (VECTORS AND SCALARS)

1. Write down definitions for the following:
   1.1 vector

   1.2 scalar

   1.3 resultant

   1.4 physical quantities

2. Classify the following as vectors or scalars: weight, mass, temperature, energy, force, and velocity

3. Draw and label the following vectors to scale (use the scale 10mm=1N)

   3.1 0.5 N to the right

   3.2 4 N to the left

   3.3 6 N upwards

   3.4 3 N downwards

UNIT 2: FRAME OF REFERENCE, POSITION, DISPLACEMENT AND DISTANCE

Motion

Motion is the change in position of a body with respect to time.

Position

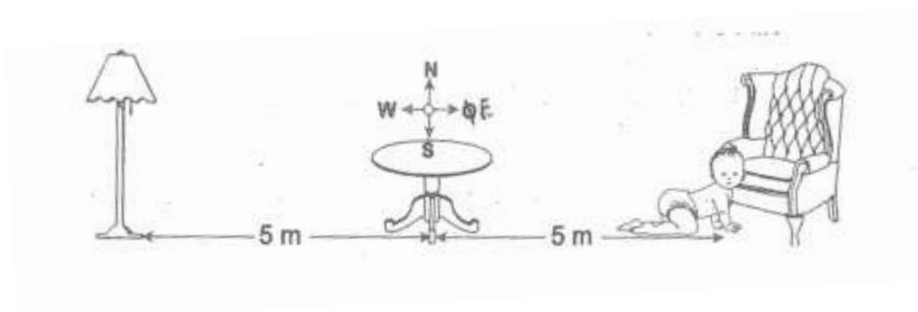
Position is the place where an object is found (as observed from a point of reference).

A position of an object at a point can only be described if there is another point or object which is referred to as a point of reference.

There are many ways to describe the position of an object with respect to its frame of reference. Two examples of such ways are shown below; can you think of any?

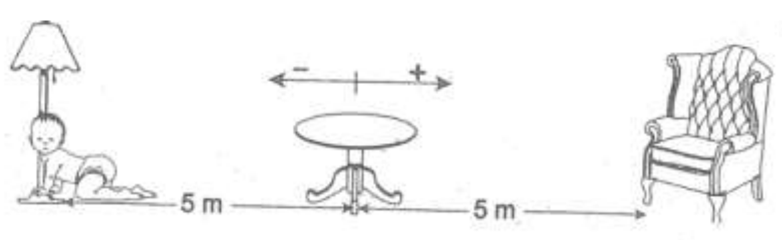
1. **Using compass directions: North, South, East, and West**

   Example: A baby crawls 5m across the floor from the table to the chair.



   With the table as a point of reference (where the baby started moving) the baby's position at the chair is 5m east (measured from the table). Should the baby crawl from the table to the lamp, his position would be 5m west (measured from the table).

2. **Left and right, or east and west, or positive (+) and negative (-)**
   Once again consider the baby's movement.



If we choose “to the right or east” as positive (+) then “to the left or west” will be negative (-).

Using the table as the point of reference, the baby’s position at the chair would be +5m.

Should the baby crawl from table to the lamp his position will be -5m.

Motion and dimension

- A car climbing a hill along a road that curves upwards and turns to the left moves in three dimensions.
- A car that moves across a horizontal parking area and turns into the parking bay moves in two dimension
- A car travelling along a road travels in one dimension. The examples and problems in this book will involve motion in one dimension only.

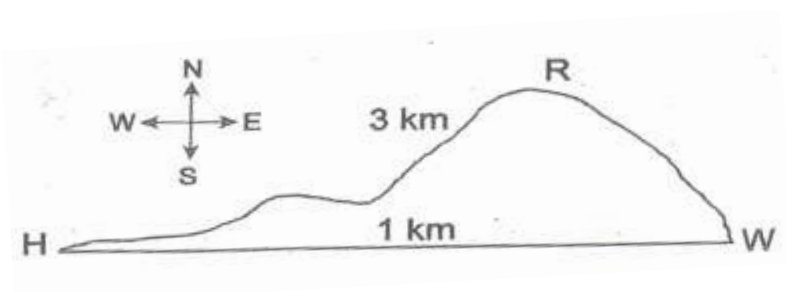
One dimensional (1-D) motion is along a straight line and can be either in one direction or in the opposite direction.

DISTANCE

Distance is the length of the path that an objects moves along from one position to another.

Distance is a scalar quantity. The symbol for distance is D and the SI unit of measurement is **metres (symbol m).**

Example: the distance from the house to the school is 3km as shown in the diagram below. This means that the actual length of the path that is followed when moving from the house to school is 1km.



DISPLACEMENT

Displacement is the change in position. It is the magnitude and direction of the straight line drawn from initial position to the final position.

Displacement is a vector quantity. The symbol for displacement is Δx (or Δy for vertical displacement). The symbol Δ (delta) means “change in or the difference in”. So Δx means “change in position”. The SI unit for displacement is **metres (symbol m)**

Example: the displacement from the house on the diagram above is 7k.

Activity 2E

2.1 Complete the following sentences:

i) A position of an object at a point can only be described if there is another point or object which is referred to as a ………………………………………………………………………………………..

ii) The SI Unit of distance is ………………………………………………………………………..

iii) Change in position is ……………………………………………………………………………..

2.2 Which word in the notes means “change in”?....................

2.3 Give symbols for the following:

i) Distance………………………………………….

ii) Displacement………………………………

iii) Delta………………………………………….

2.4 Circle the correct statement below:

i) Displacement is a:

A Scalar quantity

B vector quantity

ii) Distance has:

A magnitude only

B magnitude and direction

2.4 State whether the following statement is true or false

“One dimensional motion is always in one direction”……………………..

ACTIVITY 2

1. Define the following concepts:

1.1 Distance

1.2 Displacement

1.3 Position

1.4 Motion

1.5 One dimensional motion

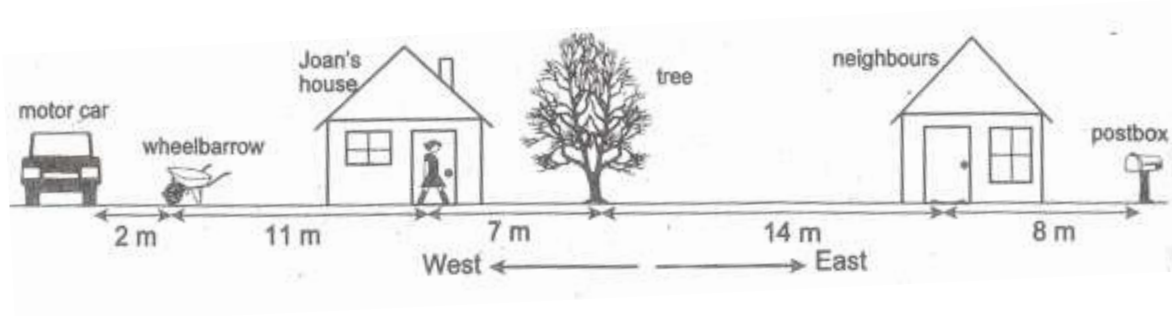
1.6 Frame of reference

2. Give two examples in which position can be described from a frame of reference.

3. In which way does distance differ from displacement?

4. Give one similarity between distance and displacement.

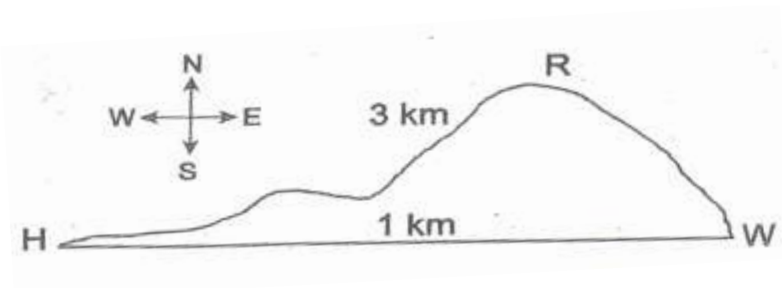
5. Joan has decided to take a walk. The following figure shows the measurements between the different objects encountered along her route.



Complete the following table that shows Joan's position relative to the starting point in different ways as indicated. **Take Joan's house as starting point and east as positive direction.**

Position	**Position with reference to different objects in diagram**	**Position using east and west**	**Position using positive and negative numbers**
Position 1	Joan is at the post box		
Position 2		21m east	
Position 3			-13m
Position 4		11m west	

6. A learner walks 3km from her home H to the shop S W along the road R as shown in the diagram below.



6.6 Write down the distance that she walked and her displacement at the shop relative to her home.

Distance:

____

Displacement:

____

____

____

6.7 Hence distinguish between distance and displacement by completing the following table:

	Distance	Displacement
DEFINITION		
SI UNIT		
VECOTOR/SCALAR		

UNIT 3: AVERAGE SPEED, AVERAGE VELOCITY, ACCELERATION

Average speed and Instantaneous speed

Average speed is the ratio of the distance covered to the time taken to cover a distance OR Average speed is the rate at which distance changes. Or

Distance travelled divided by the total time taken.

Average speed= $\frac{\text{distance (D)}}{\text{time (t)}}$

V= $\frac{D}{t}$

The word rate implies that "one divides by time".

When we take a reading on the speedometer of a motor car we are travelling in, we obtain the speed of the car at that moment. We call this the **instantaneous or momentary** speed. The SI unit for speed is $m.s^{-1}$. Speed is a scalar quantity therefore it does not have direction.

Velocity, average velocity and instantaneous velocity

Average velocity is the ratio of the displacement undergone to the time taken to undergo this particular displacement. OR Average Velocity is the rate of change of displacement. OR Average velocity is the displacement (change in position) divided by time taken.

Average speed= $\frac{\text{displacement (x)}}{\text{time (t)}}$

V= $\frac{\Delta x}{\Delta t}$

Average velocity is a vector quantity therefore it has both magnitude and direction

The SI unit for velocity is $m.s^{-1}$.

Instantaneous speed and instantaneous velocity

Instantaneous (momentary) velocity is the velocity at which an object moves at a particular moment in time (speed measured over extremely short time interval. Or the displacement divided by an infinitesimal (very small) time interval.

Instantaneous speed is the magnitude of the instantaneous velocity.

Activity 3E

3.1 Give the synonyms or one word for the followings:

i) “Momentary”……………………………

ii) “Very small”……………………………

3.2 Which words in the notes mean:

i) One divides by time……………………………………

ii) The ratio of distance and time……………………

iii) The ratio of displacement and time……………......

iv) The speed of an object at that moment…………………………………..

3.3 The SI unit for velocity and speed is……………………………………

3.4 Complete the following sentences:

i) Speed is a ……………………………. quantity while velocity is a ………………………………. quantity.

ii) This implies that velocity has both magnitude and …………………………………

3.5 State whether the following statement is true or false:

“Speed and velocity are similar because both of them are measuring how fast an object is moving and that is why they are measured in $m.s^{-1}$”…………………………………….

ACTIVITY 3

Average speed and Instantaneous speed

1. Define the following concepts

1.1 Average speed

1.2 Average velocity

1.3 Instantaneous speed

1.4 Instantaneous velocity

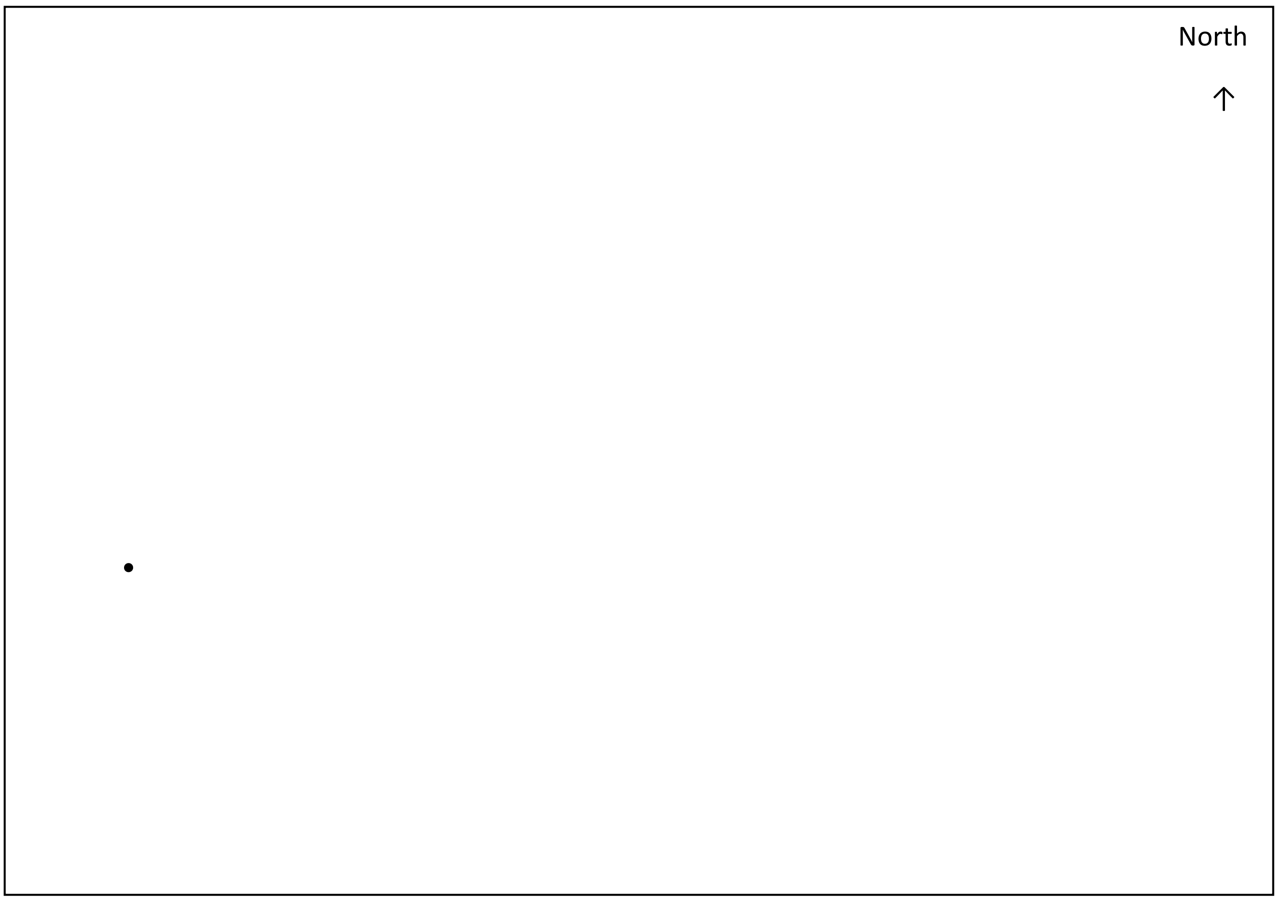
1.5 Give the synonym for the word “instantaneous.

1.6 What does the word rate implies?

2. Tom and Sally are on a cycling tour. They set out one morning from the camping site along the following

   6km North, 4km East, 3km South, 4km East, 6km South, 4km East and 3km North

2.1 Draw in the frame below, a scale diagram (where every 1cm=1km) to show the route that the followed in the seven stages of the cycling tour. Start your diagram at the point indicated.



2.2 What is the total distance covered by Tom and Sally (1) in km and (2) in m?

____

2.3 Use different coloured pencils to indicate and measure Tom and Sally's displacement at the end of the route, measured from the camping site (1) in km and (2) In m.

2.4 Explain the difference in between the distance covered and the displacement at the end of the route.

2.5 The journey along the route takes them 2 hours. Calculate their average speed for the total route in $km.h^{-1}$ and in $m.s^{-1}$.

2.6 Calculate the average velocity for the total route in $km.h^{-1}$ and $m.s^{-1}$.

---

3 A number of athletes are competing in a 400m race.

3.1 Calculate the average speed (in $m.s^{-1}$) of the athlete who completes the race in 55 minutes.

3.2 Calculate the how long it takes another sprinter to complete a 400m race with an average speed of 8m.s^{-1}.

4 A person walks 90m due east and then turns around and walks 18m towards the starting point. The time taken is 2minutes.

4.1 Draw a vector diagram to illustrate the person's change in position. Use the tail to head method and the scale of 10m=1cm.

4.2 Compare the distance walked with the person's displacement from the starting point. (Write down the value of distance and displacement)

4.3 Calculate and compare the average velocity and average speed.

UNIT 4: ACCELERATION

An object accelerates when a change in its velocity occurs. For example change in speed or change in direction of the movement. Acceleration can be defined as follows:

Acceleration is the rate at which velocity changes or

Acceleration is the rate of change of velocity

An object accelerates if:

- The magnitude of its velocity changes (e.g. if the velocity increases or decreases
- The direction of movement changes.

The term acceleration is not only used when the velocity of an object increases, but also in situations in which the velocity decreases.

When acceleration is to be determined; it is necessary to measure the initial velocity and the final velocity as well as the time taken for the velocity change.

The acceleration of an object can calculated as follows:

$$\boldsymbol{Average\ acceleration} = \frac{\textbf{change in velocity}}{\textbf{change in time}}$$

$$\boldsymbol{Average\ acceleration} = \frac{\textbf{Final velocity} - \textbf{initial velocity}}{\textbf{change in time}}$$

$$\boldsymbol{a} = \frac{\Delta\mathbf{v}}{\Delta\mathbf{t}}$$

$$\boldsymbol{a} = \frac{V_{F-}V_i}{\Delta\mathbf{t}}$$

Where:

a= average acceleration (in short acceleration) in $m.s^{-2}$

Δv=change in velocity in $m.s^{-1}$

Δt= change in time in s

V_i= initial velocity in $m.s^{-1}$

V_f= final velocity in $m.s^{-1}$

Acceleration is a vector quantity.

Acceleration is measured in metres per second squared ($m.s^{-2}$)

Positive and negative acceleration

A **positive value** for acceleration indicates that the acceleration is in the same direction as the movement. Then velocity increases.

Negative value for acceleration indicates that the acceleration is in the opposite direction to the movement. Then the velocity decreases.

Constant or uniform acceleration

We will be considering acceleration which is constant (uniform) or the same.

Activity 4E

4.1 Circle the correct answer in the following:

i) An objects accelerate when:

A Displacement changes

B Time changes

C Change in velocity occurs

ii) The rate at which velocity changes is:

A Acceleration

B Displacement

C Speed

D Distance

iii) The SI unit for acceleration is:

A m

B Kg

C $m.s^{-2}$

D $m.s^{-1}$

iv) Positive acceleration indicates that:

A Acceleration is bigger

B Acceleration is in opposite direction

C velocity is decreasing

D acceleration is in the same direction as the movement

3.2 Give the symbol of the following:

i) Final velocity…………………

ii) Change in velocity……………..

iii) Average acceleration…………

iv) Initial velocity…………………..

v) Change in time………………

4.3 Give the synonym for “constant”……………………….

4.4 Give the antonym for “positive”…………………………

ACTIVITY 4

Acceleration

1.1 What is acceleration?

1.1 A moving motor car has an acceleration of 5 $m.s^{-2}$. Explain what is meant.

1.2 A moving motor car has an acceleration of -4$m.s^{-2}$. Explain what is meant.

1.3 A truck departs from rest and reaches a velocity of 12$m.s^{-1}$ in 3 seconds. Calculate the acceleration of the truck if it originally moved westwards.

2. Complete the table which refers to this equation.

Symbol	Meaning	SI-unit	Scalar/vector
V_f			
V_i			
a			
Δt			

3.An object moving at 12$m.s^{-1}$ due north reaches a velocity of 54$m.s^{-1}$ after 5 seconds. Calculate the acceleration of the object.

3. A train travels at 28$m.s^{-1}$ to the east along the straight railway line. The brakes are applied for 7 s and it reaches a velocity of 14$m.s^{-1}$.

4.1 Calculate the acceleration of the train.

4.2 What is meant by your negative answer in question 3.1?

Unit 5: GRAPHS OF MOTION

Graphs of motion for uniform velocity

The following graphs represent the motion of a cyclist travelling east along a straight road with a uniform velocity of 4m.s^{-1} east measured over a time of 3s. Ffigure 1 summarises the information in a sketch. The position vs. time graph shows that the cyclist move 4m further along the road each second. Because the velocity is uniform acceleration is zero.

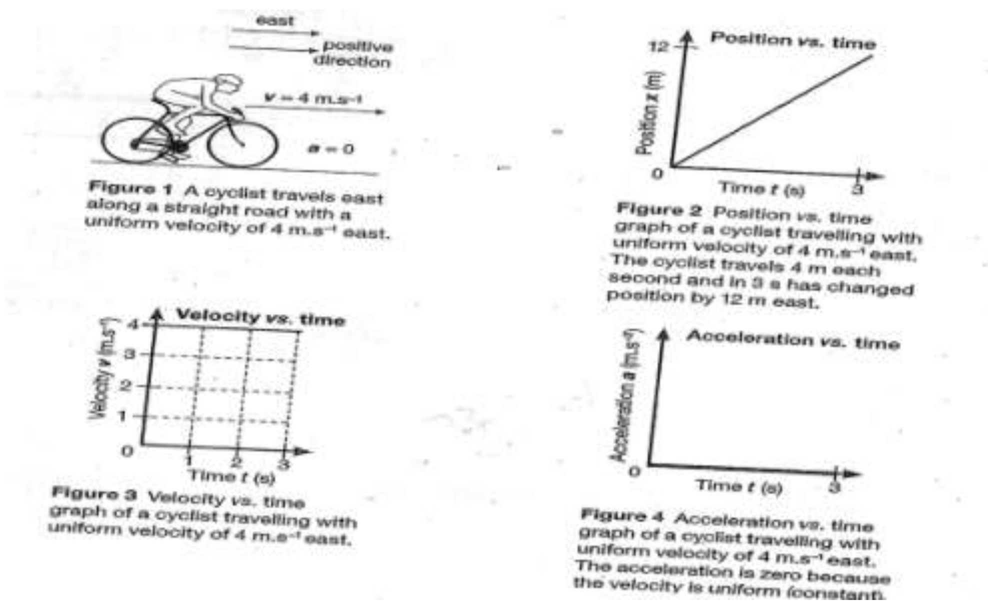


Figure 1 A cyclist travels east along a straight road with a uniform velocity of 4 m.s^{-1} east.

Figure 2 Position *vs.* time graph of a cyclist travelling with uniform velocity of 4 m.s^{-1} east. The cyclist travels 4 m each second and in 3 s has changed position by 12 m east.

Figure 3 Velocity *vs.* time graph of a cyclist travelling with uniform velocity of 4 m.s^{-1} east.

Figure 4 Acceleration *vs.* time graph of a cyclist travelling with uniform velocity of 4 m.s^{-1} east. The acceleration is zero because the velocity is uniform (constant).

Discussion of graphs of motion for uniform velocity

- The position vs. time graph is a straight line
- The gradient (slope) of the position vs. time graph equals to the velocity of the cyclist: $\boldsymbol{v} = \frac{\Delta \mathbf{x}}{\Delta \mathbf{t}}$
- The area under the velocity vs. time graph equals to the change of position (Or displacement): calculate the area under:

  Area = length x breadth

  = 4 x 3

  = 12m east

- The acceleration vs. time graph shows that the acceleration is zero

Graphs of motion for uniform acceleration

The following graphs represent a car with an initial velocity of +1m.s^{-1} east that accelerates uniformly for 5s at 1m.s^{-2} east. The acceleration and the initial velocity are in the same direction so it increases its velocity by 1m.s^{-1} east each second. (see figure 8 to 11).

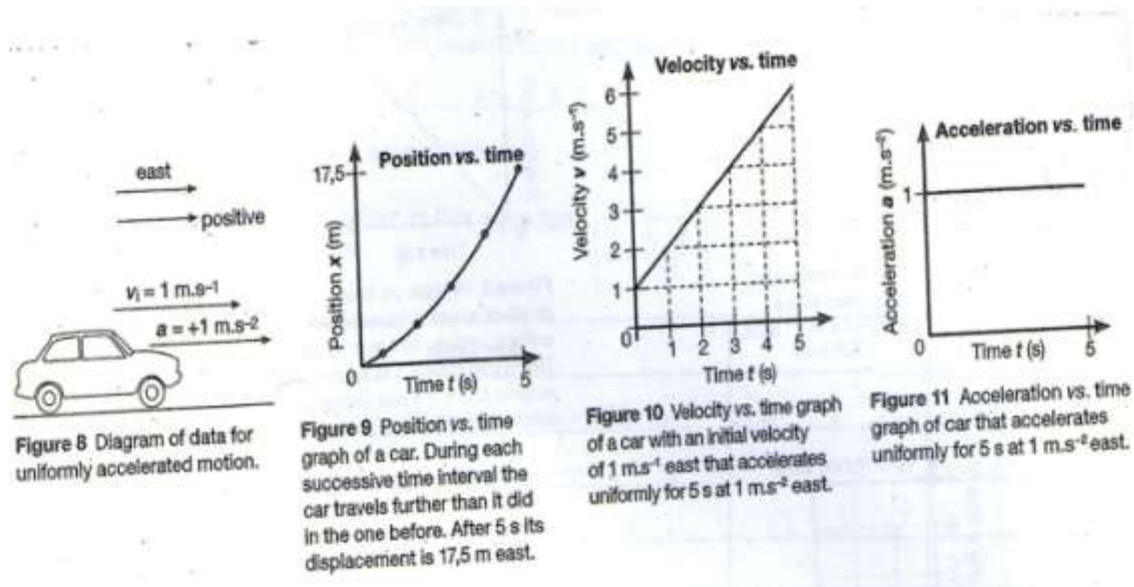


Figure 8 Diagram of data for uniformly accelerated motion.

Figure 9 Position vs. time graph of a car. During each successive time interval the car travels further than it did in the one before. After 5 s its displacement is 17,5 m east.

Figure 10 Velocity vs. time graph of a car with an initial velocity of 1 m.s^{-1} east that accelerates uniformly for 5 s at 1 m.s^{-2} east.

Figure 11 Acceleration vs. time graph of car that accelerates uniformly for 5 s at 1 m.s^{-2} east.

Discussion of motion for uniform acceleration

- The position vs. time graph has a changing slope or gradient.
- The instantaneous velocity equals the slope of the tangent to the position vs. time graph at a particular instant.
- The gradient of the velocity vs. time graph equals the acceleration.
- The area under the velocity vs. time graph equals the change of position (or displacement).
  E.g. refer to figure 10

  Area = area of rectangle + area of a triangle

  = (5 x1) + (1/2 x 5 x 5)

  = 5 + 12, 5

  = 17, 5m

Activity 5E

5.1 Circle the correct answer in the following:

i) The shape of a position vs. time graph for motion with uniform velocity is a”

A curve

B straight line

C parabola

ii) The gradient of a position-time graph equals to:

A acceleration

B speed

C velocity

iii) The area under a velocity time graph is equal to its:

A distance

B displacement

C acceleration

iv) When the velocity is constant:

A acceleration is zero

B velocity is zero

C displacement is zero

5.2 State whether the following statements are true or false:

i) Uniform velocity is equivalent to constant velocity…………………………………..

ii) Uniform acceleration means that velocity is changing with same size………………

iii) The gradient of a velocity vs. time graph equals to displacement…………………

5.3 Give the synonym of the word “slope”……………………………………

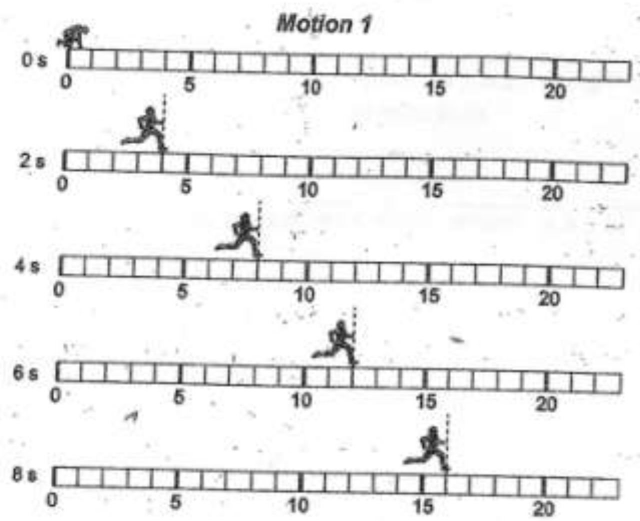
ACTIVITY 5

Graphs of motion at constant (uniform) velocity

Position-Time and Velocity-Time graphs at constant velocity

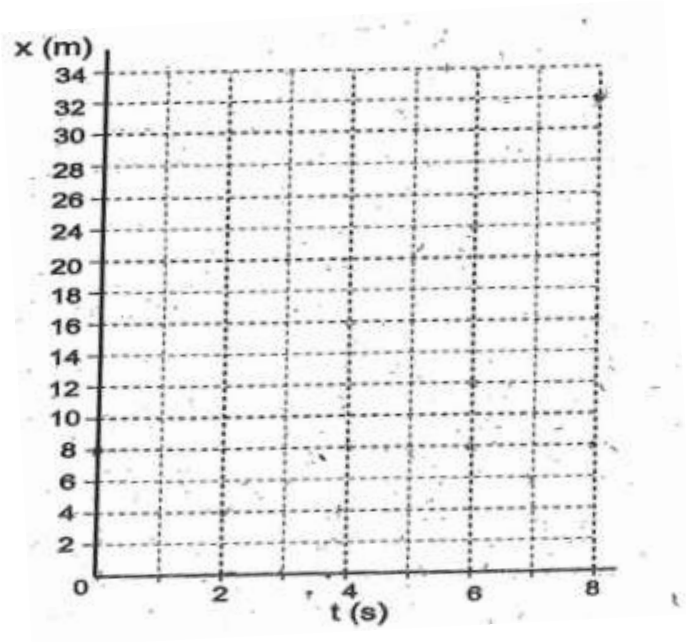
Starting at point A, an athlete runs on a straight road due east for 8 seconds.

1.1 Use the details in the following diagram to complete the given table for the movement of the athlete during the 8 seconds.



Position x (m)	Time t (s)

1.2 Sketch the position-time graph by using the information on the table



1.3 What is the shape of the graph?

____

1.4 What kind of graph is depicted by this graph?

____

1.5 In which way can the velocity of the athlete be determined by making use of the graph?

____

1.6 Verify your answer in question 1.5 by using the graph to calculating the athlete's average velocity for the total time.

____

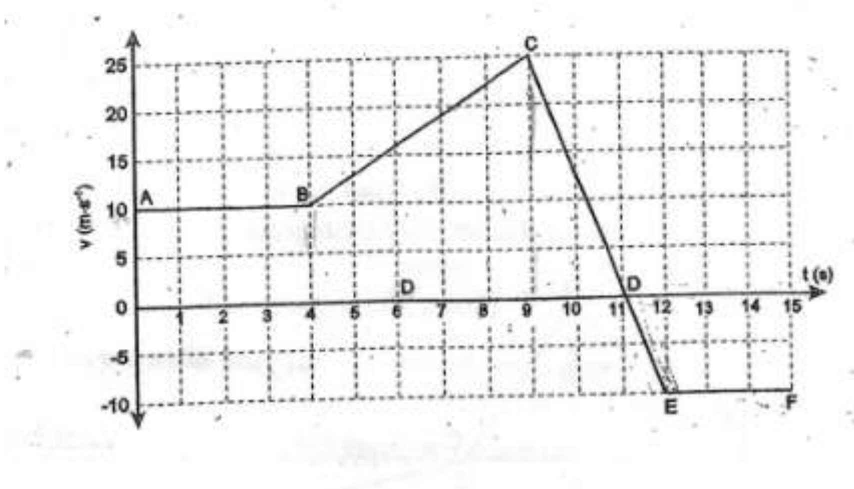
1.7 What was the athlete's displacement at 3.5 s?

____

1.8 Complete the following table relating to the athlete's movement and sketch a velocity time graph on the system provided below.

ACTIVITY 6

1. The following velocity time-graph represents the movement of a motorcycle, initially moving eastward.



1.1 Complete the following table that relates the movement of the motorcycle. No numerical values are required. Use the following words to assist you.

Increases, decreases, constant; eastward, westward; nil.

	Magnitude of velocity	**Direction of velocity**	**Magnitude of acceleration**	**Direction of acceleration**
AB				
BC				
CD				
D				
DE				
EF				

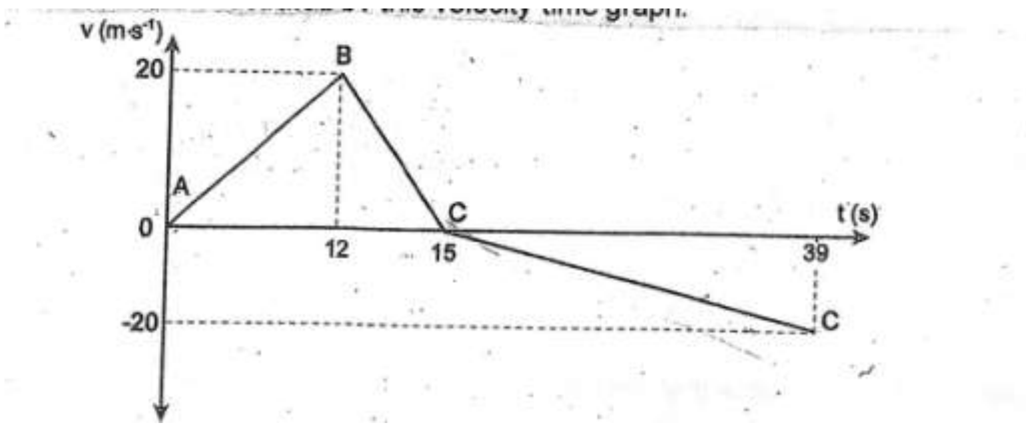
1.2 Determine the acceleration of the motorcycle for those sections of the graph in which it is not nil.

1.3 Calculate the motor cycle's displacement for the total time lapse.

1.4 Using your answer in question 1.3, calculate the motorcycle's average velocity for the 15 seconds.

1.5 Sketch the acceleration-time graph for the motion from A to D (indicate values)

2. A motor car pulls away from a crossroad travelling due west. The movement of the motor car is illustrated by this velocity-time graph.



2.1 Describe the movement of the motorcar represented by ABCD.

AB: ____

BC: ____

CD ____

2.2 At what point on the graph was the motor car furthest from the starting point?

____

2.3 Calculate the displacement of the motorcar from the entire 39 seconds.

____

2.4. Calculate the acceleration of the motor car at:

2.4.1 AB

2.4.2 BC

2.4.3 CC

2.5 Sketch the acceleration time graph for the motion from A to C

Appendix 14

Sample of transcriptions of videos for the control group

(Teacher opening a textbook.)

Teacher: We start with mechanics.

Learner: Okay sir.

Teacher: Module 7. We are on module 7. On page 211. Who can tell me what is mechanics? When you hear about mechanics what actually comes to your mind?. Ini into eza encondweni yakho (What comes to your mind). One person at a time. Ini into eza encondweni yakho (What comes into your mind?). You must raise up your hand.

Learner: kuza I Engineering (I think about engineering).

Teacher: Kuza I Engineering. O munye u cabangani (Another one?).

Leaner: uku khenica inkoloyi (Fixing cars).

Teacher: Uku khinikha inkoloyi ne (Fixing cars is it so?). o munye uqabangani (What are others thinking?).

Learner: Acceleration.

Teacher: Asifundeni la ku introduction (Let's read the introduction): Many of us we

rely on transport. We use transport every day. So I Chapter le ye mechanics it has to do with that (This chapter has to do with that).

Learners: Yes.

Teacher: It has to do with the interaction of objects and motion. I dila nga yo yonke into e hambayo (It deals with anything that is moving). Anything that is moving. We are dealing with what mechanics ne. You know that when something that is moving kune zinto o zi qabangayo (there are things that you think about when something is moving). What do you actually think about? (While cleaning the chalkboard) emuva lapho (At the back there).

Learner: Speed

Teacher: Speed ne. Omunye u qabangani (What others are thinking?). Tale (Name of a learner)

Learner: Time.

Teacher: Omunye (Another one?)

Learner: Distance.

Techer: Distance. Omunye (Another one?)

Learner: Position.

Teacher: You think about position ne. There are many things you think about. Before we talk about this we have talk about physical quantities. Physical quantities ne. Sifunu ugwazi ukuthi (We need to know) what are physical quantities. What are this things which we call physical quantities? According to our definition here; a physical quantity is a measurable property of something that we find in nature. Is something that is measurable? Anything that we can measure is called physical quantities. So if you can measure; for instance can you measure mass?

Learners: No /Yes.

Teacher: You can measure your mass. Kune scale so ku measure I mass (There is a scale to measure mass): What else can you measure? Tell me ini into onga I measure (What can you measure?).

Learner: Temperature.

Teacher: Temperature. You can measure the temperature. What else can you measure?

Learner: Weight.

Teacher: You can measure weight.

Teacher: What else can you measure?

Learner: Sugar; height.

Teacher: Height goes with distance. Those are what we call physical quantities. We call them measureable quantities. We are concentrating only on the physical quantities. Things that we can measure. For instance you talk about temperature ne.

Learner: Yes.

Teacher: You talk about time. You can measure time. Unga kgonu uku measara isikhathi (You can be able to measure time). So la basiphe ama example wa ma quantities la ne (Here they gave us examples is it so?)

Learner: Yes.

Teacher: If you measure something you understand more about it. For instance la (here) the first physical quantities is time and time can be measured in what?

Learner: Seconds.

Teacher: It can be measured in seconds ne?

Learner: Yes.

Teacher: I symbol ya khona is s. Another quantity you can measure is mass and mass I symbol ya khona I m (The symbol is m). The SI unit is kilogram and the unit of a symbol is kg. And we have another quantity which is weight and is represented by W. The SI unit for weight is Newton. Niyayibona? (Can you see it?)

Learners: Yes.

Teacher: It is measured in N. Another one is force and is measured in Newton. Unit Symbol. We have got charge. You can measure a charge. So Ama quantities lawa aya hluka (So this quantities differ), now siya wa hlukanisa (Now we separate them). Kuna na ma quantities la wa siwa biza ngama scalar quantities and kuna quantities that are called vector quantities (There are quantities we call scalars andther are those we call vectors). We have scalar quantities and vector quantities. Siqala nge scalar ne (We start with scalar). Scalars are quantities that have got magnitude or size only ne. That means lapho ubheka I size kuphela (You only look at size only). Like for instance if I ask you what is the size of your mass, you will only tell me that it is 50kg angithi?

Learners: Yes.

Teacher: I 50kg leya is only i….? (The 50kg is only….?)

Learners: Size.

Teacher: it a size niyabona (You see?) So ama scalar quatities ilawa si considara I only I size (In scalar quantities we consider size only). For instance i temperature if I ask you about temperature, You will only tell me that it is 15^{o}C ANGITHI (Is it so?)?

Learners: Yes.

Teacher: angeke ungidjele ukuthi it is 15 ^{o}C to the south angithi degrees celsius to the south). (You won’t say is that. Is it possible?)

Learners: (laughing) No.

Teachers: You can’t say that ne?

Learners: Yes.

Teacher: So ama scalar quantities I lawa si considera is size only (Therefore in scalar quantities we consider size only). You can’t talk about only the size only. You also have to mention the direction. When we talk about other things we can’t talk about only the size. You also have to tell me the direction. For example let’s compare abantu aba I two laba a pilot and umuntu o driver imoto (Lete compare a pilot and a car driver who will need direction more than the other?)

Learners: Pilot/we moto (The car driver).

Teacher: Others are saying the pilot and other says the one with the car. Which one is correct?

Learners: The pilot nguye o needa I direction because mau hamba e moyeni akuna zindlela (The pilot will need direction the most because there are no roads in the sky). There are roads iin the air? uzo yazi njani ukuthi ngi hamba nge ndlela e right (Ypu will not know where you are going). Ene a kuna festere yo kuthi ngi hamba endleleni yase Moloto (There is no window to check if you are now in Moloto). Ngubani o dinga I direction kakhulu (So, who needs direction the most?).

Learners: (In chorus) Pilot.

Teacher: The pilot; because umuntu o hamba nge moto u yo phuma la nala and maga fika le a thole I board ethi Pretoria (The person with the car will follow the roads and the board will also direct him/her to Pretoria). So u ya bona ukuthi akadingi kakhulu I direction (So you can see that he/she does not need much direction). So that's why ngithi kune zinto ezinge mauzi explaina you have to mention (That's why I say that are things when you mention (Disturbance somebody borrowing a duster).ni ya ngizwisisa ne ngune zinto ezinye ma u khuluma ngazo you have to mention both the size nad the direction (Do you hear me there are things when you mentioned them you will need both magnitude and direction). Let's say I have my aeroplane or hellicpoter I want to go to Moloto uya bona a kuna ndlela e khomba ukuthi kuiwa njani e Moloto (You can see that there is no road in the sky showing direction to Moloto.) The first thing I will need to know what is the direction to Moloto and the second thing is how many kilometres to Moloto. So I know that mangihambe 10km se ngise duze no ku fika e Moloto (I know that after travelling 10km I am nearly at Moloto). Then se ngiya bheka bheka langi yo lender khona (I check where I am going to land. BUT that's why other quantities needs both direction and size. But when we talk about mass, there is no need to tell me about the direction of the mass, is there a need?)

Learners: No.

Teacher: There's no need niyabona (is it so?). There's no need for you to tell me that you are 50kg to the south.

Learners: Laughing. No.

Teacher: But if I ask you what is the size of your shoe, you can't say size 4 to the left.

Learners: Laughing.

Teacher: is it possible?

Learner: No.

Teacher: You can't say that ne. La sikhuluma ngamaquantities adinga only is size kuphela (Here we talk about quantities that need magnitude only). I magnitude iya fana ne size ne (Magnitude is the same as size). This word and size is the same thing. I size I sebenzisa ngama lay people (Size is used by lay people). Lay people who are not science literate. Nina ni science literate (You are science literate). Kuwe angeke sithi what is the size but we will talk about magnitude of the force (With you we can't say what is the size but we say what is the magnitude of a force?. I knowledge yakho I phezulu kanqane (You have more knowledge). Angeke u khulume no gogo nge magnitude but we talk about size (You can't talk with your Granny about magnitude). Angeke uthi gogo what is the magnitude of your shoe ozo mangala. Wena you are a scientist to be (You can't say grany what is the magnitude of your shoe, she will be surprised). There is a language of science and lay people language. u ya understand that kuna ma vectors and a ma scalars. Now let's see what is the difference between scalars and vectors. Scalar quantities can just be added and subtracted like ordinary numbers. Just like in temperature you can just add them like ordinary numbers. But when you add vectors the direction has to be taken to consideration. Let's say for instance u ya hamba (You walk), 5 m to the right and u ya buya u hambe (you return by) 3m to the left. If there are scalars and ask about the distance; you will just add 5+3=8m. if there are vectors you have to consider the direction; the first thing you must choose one side as positive, so let's we choose right as positive and left as negative we will end up with 5+ (-3)= 2m to the right. Kune (There are) negative scalar and vectors. A negative vector has the same magnitude as the other vector but act in opposite direction. Let's say we have 5m to the right and 5m to the left. According to ama (the) vectors this two are equal. Ku (in) maths this numbers are not equal. Which one is bigger?

Learners: Positive 5.

Teacher: Positive 5 is the bigger number. Inegative 5 Inumber? (You mean 'inegative' and 'inumber'?) enqane (Negative 5 is a small number). But kuma vectors a ma number la aya lingana (But in vectors these numbers are equal), they only differ in direction. The other one will be 5m to the right and enye (The other one) will be 5m to the left. With scalars they are all equal. For example -10^{o}c and 10^{0}c are not equal. Sina ama example wa ma vectors and example yama scalars (We have examples of vectors and scalars). For example mass is a scalar quantity , time is a scalar quantity, weight is a vector, force is a vector. Asiboneni ukuthi si indicate njane I direction (Let's see how we indicate direction). We use south, north; right etc. Graphical representation of vector is represented by a vector by a line with an arrow. For instance let me draw 10m and 5m. The length represent the magnitude therefore the line for 10m will be bigger than that of 5m. We are going to draw vector diagrams. Do have rulers. At-least on one table there must be a ruler. We are doing practical activity 1. Lamathomo (first) you have to indicate direction. Look for the blank page. You will draw a force of 400N upwards.

Draw a small line that is going up. The second part decide on the possible scale. 1mm represent 1N. therefore 400N will equal to 40mm. now draw that line to scale. It is very much that you draw it to scale. Ni yabona ukuthi kulula njane, ngizo nikela enye futhi (Do you see how easy it is? I will give another one) . (Learners drawing for 30second) nixedile (Are you done?) (Teacher talking to the learner saying this is not forty) (Some learners still continue). But asi forty mo.i Forty ilingana ne 4cm (Some learners still doing the activity) This is our first practical activity. Let's do the one for 200N to the right.

TECHER: (Learners still working on the drawing for 200N to the right). Another one 700N to the left. All the time you will have to know the direction. Another one 1200N downwards. We still use the same scale. If you are done I will give you a homework for vectors. Make sure that you come with a ruler tomorrow. Period comes to an end.

Appendix 15

Sample of transcription of videos for the experimental group

We are about to start. Today we start with the topic of mechanics. What are we actually studying in mechanics?

Learner: How to fix things?

Teacher: How to fix things. Another one?

Learner: We study our environment.

Teacher: Our environment.

Learner: We study about engines

Teacher: Engines. So it has to do with mobiles. In reality we are going to study about motion. Anything that is moving. Before I start with this I will give you time to do activity 1E. How much time must I give you? Now it is your time.

(Silence for about ten minutes, while learners work on activity 1E. All of them look focused to the activity. It is like they are writing a test or an examination)

Teacher: Now we are going to discuss the questions. What did you feel when you complete the question?

Learner 1: I thought it was a difficult question but it was not.

Teacher: Let's look about the first question. Which word in the notes means a measurable property of something we find in nature?

Learner: Physical quantity.

Teacher: Physical quantity ne (Is it so?). When we talk about a physical quantity. Let's talk about the word physical. In physical science, especially in physics we deal with physical quantities. A quantity is something that you can measure. For example; temperature. You can be able to tell that in this classroom is 20^{o} ne. What other quantities can you measure?

Learner: Mass.

Teacher: Another one?

Learner: Time.

Learner: The weight of a person.

Teacher: Another one? Learner: Force.

Teacher: You can measure force. We call them quantities because are measurable. Especially in physics we are going to look at quantities in mechanics when something is moving. When something is moving you ask yourself what is the distance of that object. Si yo khuluma ngezinto ezifana na lezo (We are going to talk about things like that) . We are going to talk about time; mass, distance and force. Which of the following is not a physical quantity?

Learners: Distance, Newton, energy.

Teacher: Newton, Newton is not a physical quantity. It's a unit for a physical quantity. For instance is a unit for force. It is an SI for force. A force is a physical quantity but Newton is not a physical quantity. Mass is a physical quantity; and is measured in kg and energy is a physical quantity and is measured in Joules. Distance is a physical quantity and is measured in metres. Which word in the notes is a synonym for size?

Learner: Magnitude.

Teacher: magnitude ne. Ko science ge re bolela ka size ne, when we talk about size (Interruption noise) what if I say what is the magnitude of your shoe. What would I mean?

Learner: Size.

Teacher: What is your shoe size *ne*. But you must say the magnitude of something. You must say the magnitude of a force, a magnitude of a mass or magnitude of a distance. In layman's language we call it size and in the language of science we call it magnitude. State whether the following statements are true or false. A vector quantity is a physical quantity with magnitude only.

Learner: False. A vectors quantity has magnitude and direction. The second one: A negative vector has same magnitude as a given vector but act in the opposite. Derrick!

Learner: True.

Teacher: True, a negative vector enale (has) same size ne. If we say that something is a negative vector, let's talk about displacement you travel 50m this side and another one travel 50m the other side. You can see that they have the same magnitude but differ with direction. For instance if I want to go to Pretoria, ke tlo (I will) need a direction.

Learner: Yes/ No.

Teacher: Ke tlo needa (I willneed) direction serious. I would not need direction because there are roads. But somebody with an aeroplane will need direction. The only thing I will need is direction and the kilometres. Because emoyeni (In the sky) there are no roads. Uhamba strate la u ya khona (You go straight where you are going). Unless if u yo lenda (Unless when you land); kuna ma traffic controllers (There are traffic controllers) .People who are on the ship or aeroplane need direction but with the car you don't need direction because there are roads. The board will tell you that you are going to Pretoria. The next question is that a negative vector is less value than the other.

Learner: True.

Teacher: Is it true? No it is false. If you have positive 4N and a negative 4N with vectors they have equal in magnitude. The only thing that they differ with is direction. What is the meaning of a vector diagram?

Learner: It is a graphical representation of a vector.

Teacher: Is a graphical representation of a vector. The resultant is found by?

Learner: Adding.

Teacher: Siya (We) add. The length of an arrow represents?.

Learners: Magnitude of a vector.

Teacher: Magnitude. For today we are done. Any question?

Learner: Can you explain to me about negative vector with regard to the last paragraph of -10 degrees Celsius and positive 10 degrees Celsius?

Teacher: In this case temperature is a scalar quantity that's why positive 10 degrees Celsius is bigger than negative 10 degrees Celsius. Hambani ni yo funda ngazo (Go and study about them). We will talk about them tomorrow.

(End of lesson).

Appendix 16

Transcriptions for the focus group interview

Introduction

Eh, as I said that, eh we are going to do the interview, and then what you need to know gore what we do here, eh it is confidential, it very much confidential, it is only me and you who will know about this information. That's why I say to you must not be afraid to say anything, eh maybe thinking gore no batho batlo go sega or things like that. You just be free and participate in (Disturbance).

Researcher: What make physical sciences difficult as a subject according to you? What makes the subject difficult, physical science? Since you have been learning physical science, what makes it difficult? Eh yes.

Learner 1: The language that we are speaking at home and the language of science and the language we are speaking at school.

Researcher: Ok; the language ne. and then the other one. What makes this subject difficult? Ini into enza ukuthi ibe difficult. Eh yes.

Learner 2: Ma unga stadishi sir.

Researcher: If you do not study ne.

Learner 2: Yes.

Researcher: OK Omunye?

Learner 3: Ama calculations

Researcher: The calculations ne?

Learners: Yes.

Learner 4: U studishe bese unga understandi.

Researcher: If you don't understand what you are studying ne? Yah. Another one?

Learner 5: Ukuthola amathishere a vilaphayo so.

Researcher: Oh lazy educators, OK. Then abanye bathini.

Learner 6: Abo mam aba nga understandeki. Singa stadishela thina. If ever uMam u ya understandeka, ku zo ba lula uku zi bamba.

Researcher: OK, OK. Then before we move to another question is there anything enifunu ukuyi adda?

Learner 7: Taking the subject for granted.

Researcher: Taking the subject for granted. That's good. And then another one? Yes?

Learner 8: Ukuthi sir ma u bona ukuthi umnyaka u yaphela, kuba auka sifundisi, usi fundisa masinyana u yabona.

Researcher: Yah. You are right. That's very good points. All of you have mentioned very good points. We can move to the next question ne. Yah I think we have exhausted this one. The next question do you think that language affect the pass rate in science? Does it affect the pass rate?

Learners in chorus: Yes.

Researcher: Asikhulumeni maybe one by one. Si khulumeni ukuthi why ni qabanga ukuthi I affecta ipass rate eh yes.

Learner 1: Ga e tshwane le language ye re e usago ko gae, dilo tsa teng di a difara.

Researcher: OK.

Learner 2: Ama words akhona, like they are more complicated, ukuthi u nga wa bamba entlokweni yakho vele, so if wena u ya studisha like in every day, u wa practise like by talking them no ma ungu bani like i centre so, masi wa khuluma si communicate ngawo I think things very easy.

Researcher: OK. Omunye. Nyi bona u ngathi be umisi sandla.

Learmer 3: Be ngi yo khuluma nje ngaye mara ngi funu uku adda. If ever abdisi and asi khone kuwa pronouncer , vele angeke siwa bambe.

Researcher: OK

Learner 4: I wanna say like if you ask them to explain something, then the teacher will use mother tongue not in simple English, I think it will be simple if he or she explain in simple English because in our mother tongue we will not be able to put it in English.

Researcher: OK, omunye. Another one. What is your overview? Ya affecta or ayi affect. Just your views. I just need your views. Eh buti.

Learner 5: Key a greeya sir. Gabotse each and every teacher ahlalose, entlek the whole school e swanetse e be le language e ee berekisago in class.

Researcher: OK. Ke ya leboga. Re movela go ennwge question ne.ok. eh. What language do you prefer to study with? I mean Physical Science, do you prefer it to be taught in which language? In which languge are thome kamo?.

Learner 1: English.

Researcher: Why do you prefer English?

Learner 1: Is because go nale mantsu amangwe oka se kgone go a pronouncer in our mother tongue mara aka English.

Researcher: OK eh.

Learner 2: The same.

Researcher: OK the same.

Learner3: English.

Researcher: English. OK reason?

Learner 3: Because sir is like ke language e re e berekisago go communicator le batho and ge diquestions tsa physics di tla ka sekgowa.

Researcher: OK.

Learner 4: Keya dumela.

Researcher: Wa dumela.

Learner 4: Eh.

Researcher: Which language do you prefer?

Learner 4: English.

Researcher: You prefer English?

Learner 4: Mm.

Researcher: OK.

Learner 5: Mina sir ngi prefer I English ngoba eish isiNdebele , u yai bona I H_2O iH_2O ngeke wa I biza nge sindebele. Sir u ya bona nawe. I hambili ou.

Researcher: OK mo key a ka line, ke tlo li botsisa kamoka jwale. Eh Lillian?

Learner 6: Oh me I will prefer English.

Researcher: You prefer English. OK.

Learner 7: Lenna ke prefera because the most language ere ka communicating ka yona re kgono utlwisisa ke English.

Researcher: Ke English ne OK eh.

Learner 8: Mina ngi prefer iEnglish just because i physical science ina amaelements.

Researcher: Yah.

Learner 8: Amagama wa khona azoba difficult if ever ngi wa sebenzisa nge sindebele cause ngingumdebele angeke ngithi hambili ou. I better say H_2O.

Researcher: OK.

Learner 9: English.

Researcher: English ne. wena o preferang.

Learner10 : English.

Researcher: Ok wena o prefer language efeng sesi?

Learner 11: Home language

Researcher: OK.

Leaner 12: English.

Researcher: Eh ko morago kuwa.

Learners: English.

Researcher: English re ya feta ne.

Learners: Yes.

Researcher: Yah and then?. The next question, how are taught reading in English classroom? What types of articles do you usually use when you are reading when you learn reading strategies? Do you sometimes read science articles in English classroom?

Learners (few learners): No.

Learner 1: Yes we do.

Researcher: Le ithuta ka eng English ko claseng gale i thuta reading what type of articles do they use?

Learner 2: Short stories, poems, and akuna science.

Researcher: Akuna science ne. ok nawe o sho njalo. Ok. Ke kwele omongwe are e teng science? Ikhona ne.

Learner 3: Mina ngithi ikhona.

Reaearcher: OK, OK.

Learner 3: OK I can see some of the stories are having science cause like we like in this other stories we learn about hymenia, hymenia this desease, we learned about the person who is diagnosed with bleeding gastric, we did not know that , and that is part of science.

Researcher: Is related to science. OK.

Learner 4: Think sir namanje you can say water and you can transfer it Ain English angithi ku Physical Science they can take H_2O and they say ibale nge gama so kushokuthi siyayifunda.

Researcher: OK, OK. Omongwe o reng. Di story tse le di balang ko english are they related to science.

Learners: Some.

Researcher: But most of them eh what do you think, are they general or are they related to science?

Learners: General.

Researcher: General OK OK, and the next question do you think that incorporating language can help in understanding the subject better? When we say incorporating we mean that amastrategies that they are using in English we implement them in physical science classroom in order to make you understand. Do you think that can help manixabanga?.

Learner 1: Yes.

Learner 2: Yes.

Learner 3: Maneer mina angikakuzwa.

Learner 4: Nami angika muzwa.

Researcher: Oh anikayizwa I question, if maybe see incorporate sisebenzisa, sithatha some of the strategies ze English, siziletha ku Physical Science let's say maybe size ne article ye physics, and then mara ini fundise I englsih sibuze maybe ngama synonyms, ngama antonyms, ngama adjectives but the story you find that the story is about science. Will that help mani xabanga nina.

Learners: Yes.

Researcher: Inganixeda ne?

Learner 6: A lot a lot.

Researcher: Maybe who will like to expatiate more about it kuthi how will it help you. Unga funu ku qwalisela ukuthi izomuxeda njani?

Learner 7: It will help us like if we read those stories and you will read them from lower grades until matric those things will be there or we won't forget them and if they are in physics they will be fine.

Researcher: OK OK siya contina ne. The next question do you think that physical science has got its own distinct terms from other disciplines. Ngisho ukuthi na ina mawords, the words that are not found in daily lives.

Learners: Yes

Researcher: Ngifuna ningiphe nama examples, can you give examples of such terms, such terms la nibona ukuthi la akhona akhona ku physics but in real live ani wa thole.OK.

Learner 1: Igama leli i stoichoimetry, u yalibona, ngilazi nge physics kuphela.

Researcher: Stoichometry, ok omunye u xabanga liphi.

Learner 2: Chemistry.

Researcher: Chemistry yo yo ok omunye anga thini.

Learner 3: Carboxylic group.

Researcher: Omunye another word?

Learner: Double bond.

Researcher: I think a enough ne?

Learners: Yes.

Researcher: OK I am going to number 8 question 8. How does the language used in physical science compare with the language that is used in other discipline. Ehh zihluka njani i language esi yi sebenzisa ku physics e I difara njani with other. Which one of them is difficult? Which language is difficult?

Learners : Physical science language.

Researcher: Physics, physical science language. Eh sesi?

Learner 1: Yes It is more into science, into science thing, ayi khulume nge reality ngezinto eziyenzeka empilweni zethu.

Researcher: OK OK i different ne?

Learners: Yes.

Researcher: We move to the next one. Eh how best do you think physical science should be taught? Nixabanga ukuthi sifanele si yi fundise njani i physical science according to you. Eh yes?

Learner 1: If ever like they teach it from Grade 4, they teach it from Grade 4, ui khethe from Grade 4, ukhupuke nayo njalo. Hayi ukuthi sifunde i social science last year. Ku xono ukhule u yazi u kuthi i physics le, ukhule nayo'.

Researcher: OK OK, then omunye u thini?

Learner 2: Maybe Grade 4 e fase thata a e ka thoma ka Grade 6.

Researcher: Grade 6 ne? Yes.

Learner 3: Masingakhuluma I language ye science, si increase siyikhulume ema Khaya sikhulume yona nje ngabantwana be science. I think izoba better.

Researcher: OK. Ko morago kua lereng lena. How best do you think physics should be taught according to you?

Learner 4: Physiscs eswanetse go ba le di period tse dintsi go swana le maths.

Researcher: Oh ebe le enough periods ne?

Learners: Yes.

Researcher: Ok , kamo arekwe ka mo lereng bo sesi kamo?

Learners: Grade 1

Reseracher: From Grade 1. OK OK.

Learner 5: Ebe le di experiment tse dintsi.

Researcher: Di experiment tse ntsi ne? OK.

Learner 6: Like a teacher even a teacher is talking to us like physical science way not the English way.

Researcher: OK, OK.

Learner 7: If ever banga changer the school i be I science school I think izo ba better.

Learner 8: I chapter enye ne enye like basitsengise si ngayi khulume ngomlomo o thole ukuthi nawe u mam au ka yi bona.

Researcher: OK.

Learner 9: Eskaba theory based, ebe le di practiacal.

Researcher: Ok omongwe. Le feletse.

Learner 10: Like I wanted to say the number of bana ka mo classeng maybe ratio ya gona ebe 1: 30 or 1: 20.

Researcher: OK leskaba babantshi, learner teacher ratio. OK OK before we move to the other question. Le right. What will you like to add? Anything that is in your mind?

Learner 1: More qualified teachers to teach science sometimes you find you find ukuthi abanye abo teachere aba si qualified and they give you a very big, inkinga vele.

Researcher: OK.

Learner 1: Kumele si be na ma poster siforme na ma science group like hy ukuthi si stadishe.

Researcher: OK eh.

Learner 2: Giving certificates to learners who perform well in physics. This will motivate like other learners to pick up their socks.

Researcher: OK they see the certificate ne, motivations. Ke bone o emisitse letsogo?

Learner 3: Ya swana le ya gagwe.

Researcher: Ya swana ne? OK.

Learner 4: Ne ke nagana gore mathishere are rutang like aseke a berekisa like bona ba tseba ka ga yona, like ga bare explainela ba se ke ba re felela pelo, bare explaine pila ka english e simple.

Researcher: OK.

Learner 5: Also like if our teacher can teach only in Grade 10 not teaching also Grade 9, because you find the teacher running to Grade 9.

Researcher: OK.

Learner 6: Kufuneka ku be ne trip yo kuya eskolweni esinye , umnyaka lo azange sibe ne trip.

Researcher: OK.

Learner 7: Go swanetse go be like library so that re be le more books tsa science. Library.

Learner 8: Go swanetse ba efe nako gore re kgone go utlwisisa.

Researcher: More time ne. omongwe.

Learner: Ko clasSEng ya science go swanetse go be le TV ba kentshe CD bare bontshe nthwe re ithutang ka yona.

Researcher: OK. Anything si yabonga for all your inputs they were excellent. I think they will take us very far as educators.

Appendix 17

Transcription for interview for teacher 1

Researcher: We are about to start ne. What I wanted to assure you is that the information given here will be strictly confidential and your name will not be mentioned in any of the reports. So the first question that I will like to ask is eh how many years teaching experience you … how many years have you been teaching in general? From which year have you been teaching?

Teacher: I started teaching in 2006.

Researcher: OK and specifically physical science how many years have you been teaching it?

Teacher: Hm, I have been teaching physical science for five years.

Researcher: OK, OK and then the first question is how does teaching physical science compare with teaching other subjects?

Teacher: Hm I can say teaching physical science, is more challenging than teaching other subjects for instance if one has to teach physical science the experiments has to be used, but let me take eh the language , language can be theoretical but science cannot be theoretical, it should be theory plus the experiment the learner will understand physical science better when experiment has been done.

Researcher: OK, OK, the second question does this make teaching physical science easier or more difficult to teach than other subjects. Remember the first question you were comparing the two, now they want to know gore does this make the subject to teach than other subjects.

Teacher: OK let me respond according to the way two terms that have been used, the easy part and the difficult part I can say teaching science will be difficult if there are if the school doesn't have the apparatus maybe the school is poor and it's a disadvantaged school but it can be easy if the apparatus are there and learners will experience the easy part of doing science.

Researcher: OK OK question number 3. Do your learners see physical science as a difficult subject or as an easy subject? What do you think makes them think so?

Teacher: I will go back to number 3 on the difficult and the easy subject, some will see the science part as a difficult one but some will also see it as an easy one for those who see it as difficult subject are the lazy one because of their laziness, sometimes the laziest learners you can also find them in class are those who will see the subject as difficult one because of their laziness, but the hard workers they find it easier because they give themselves time to go through everything that is in science.

Researcher: OK, OK fifth question, eh do you see physical science as a difficult subject? Explain.

Teacher: Ah I can say for me science is not easy I will say is much challenging because from time to time one has to teach this subject without the apparatus we have already mentioned above and you will have to teach the theory part we cannot tell the learner about the certain colour of a chemical that they never seen. Some learners do not know the chemicals.

Researcher: OK, OK what makes physical science difficult as a subject according to your view, what makes it difficult or factors that makes the subject difficult?

Teacher: Hm I will say previously we have been told that physical science is difficult and then we have got this I don't know I can call it a myth or what that say science is difficult because is like we have planted this information in our head or our mind that science is difficult even though is not difficult.

Researcher: OK OK the next question, does language has an effect on the pass rate? Explain.

Teacher: Yah I will say the language also has an effect on the pass rate because if, If a Ndebele child has to do the science with English some of the terms or the words cannot be found in the western or English language though you found that learner will find it difficult to understand because for instance they will take, they will know this, what can I call it, it's like a medicine, they call it umthuma ne

Researcher: OK.

Teacher: Umthuma they use to heal the decaying ne. Only to find out they will not even know what umthuma used in English language so that is why I am say that it will be much easier to them to do all the science in their own language. They will find it easier and I think it also improve the pass rate.

Researcher: OK eh question number 8 is related to question number 7 what language will you prefer learners to study with, eh especially physical science?

Teacher: Hm in their home language, depending on the environment they are living in like for instance let us take Sun City the majority of the learners are Ndebele ne.

Researcher: OK.

Teacher: So, in Sun City they are living in the former KwaNdebele and majority of the people here are speaking Ndebele they will find it more easier to them to understand even the Pedi speaking learners they do understand the Ndebele language but go to Nelspruit, even though is the same province Nelspruit is Mpumalanga the the learners there I should think they can use the Swati language because they understand the Swati better than any other language it will depend on the type of environment they are in.

Researcher: OK, OK question number 9 do you think that English language teachers must use articles, science articles when they are teaching reading in their classroom? Must they use science articles?

Teacher: Ah yah, I think, I think that they can use that science articles but only to find that it will also be difficult for them because they cannot use science hence they did not do science at school it will be just like photo frame pasted on the wall because they will not be able to understand any type of the thing pasted on that article.

Researcher: OK.

Teacher: But I will say that some can use it if they do understand.

Researcher: OK OK. Do you think that incorporating or integrating language reading strategies in science classroom can help learners in understanding the subject better?

Teacher: Reading strategies in science classroom, I should think so.

Researcher: Why do you think this can help them in understanding the science part maybe they are taught, the language is integrated with eh physics in the classroom?

Teacher: Ah I think that if they can incorporate or integrate this language it will be easier for them because hm I should think that all the learners are doing the language at school the English language if this thing, if the science is integrated in their reading in their classroom it will be easier for them find that if for instance there are given the comprehension that deals with science I should think that they will find it better or much easier for them to understand this subject much easier because they will be free to ask any question concerning them.

Researcher: OK OK the next question how does the language used in physical science compare with language used in other disciplines. You can also give example here.

Teacher: OK we compare the language used in other discipline?

Researcher: In other words I mean the terms, the terms that are used in physical science how do they compare with the other terms they use in other discipline like in life orientation, like in geography are they the same or they are not the same maybe you can even give examples?

Teacher: Hm I can say they are the same sometimes they are the same this terms that are being used compared to the language sometimes they are not the same like for instance I will say take a Grade 10 given the type of investigation, let us say they are running an experiment ne, if they are running an experiment or they are doing an experiment there will be an investigative question they have to go through the comparison, the research all those the hypothesis only to find that if they has t to do science they will be a hypothesis it won’t be the same as those used in language so sometimes I will say some words are more difficult in physical science to understand than in the English part or in the language.

Researcher: OK, OK the last one how best do you think physical science should be taught? The strategies, teaching strategies that can be used to teach science which teaching methods or the strategies work in teaching the subjects?

Teacher: I will say hm, the strategies that can be used in teaching science the learners must be given the research type question, they can also find hm, install the internet on all the science schools for the learners so that they can also communicate with the other experts that teach science like you can see hm we have got the channel that do science if they learners find the difficulty because sometimes the teachers can also have the problems so he or she will feel free for learners to communicate with the other expertise outside the teaching environment.

Researcher: OK OK the last question; what else will you like to add? Anything you will you like to add that is related to science teaching or related to science?

Teacher: OK I will say science is a very hm enjoyable subject. people must not find science as a difficult subject like I always said above because like I have said people have this theory that science is difficult the learners just come and say I am here to take chances because someone has told me that science is difficult so learners has just have to grasp the information given and explore the world. .

Researcher: OK, thank you for your time I think that will be all for today.

Appendix 18

Transcriptions for interview Teacher 2

Researcher: As you know me sir my name is Mr Hlabane yah so I am just going to ask you some few questions. But I assure that the information given here will be strictly confidential and your name will not be mentioned in any part of the report. So that is the assurance. And then first of all maybe I will ask you how many years have you been teaching?

Teacher: Eh I am now in 16 years of teaching.

Researcher: Sixteen years teaching? How long have you been teaching physical science?

Teacher: About ten years.

Researcher : Ten years. OK maybe if you can be audible enough for the sound. Ten years in teaching physical science. Ok. The first question is how does teaching physical science compare with teaching other subjects?

Teacher: Yah eh teaching physical science compared with other subject is that when you are teaching physical science the teacher should not be lazy, you must always be reading, calculating, practicing so that you don't forget so that when go to class you are going to teach you can be able to deliver.

Researcher: OK OK, the second question does this make teaching physical science easier or more difficult than other subject?

Teacher: No teaching physical science is more difficult to teach you must always be doing practicals, reading, calculating, so is more difficult to teach physical science than other subjects.

Researcher: OK, do your learners see physical science as a difficult subject? Oh as a difficult subject or easy subject to learn what do you think make them think so?

Teacher: No the because, physical science is not difficult but it is eh challenging but this learners they are lazy to read and practice that's why they find difficult in physical science but is not difficult but it is challenging.

Researcher: OK the next question; eh do you see physical science as difficult subject? Explain.

Teacher: No it is not difficult but is challenging you need, Physical Science doesn't need a lazy teacher, and you need a teacher who is always hard working.

Researcher: OK OK, on the side of the learner, what do you think, what should the learners do in order maybe, do they, do they, what makes it makes it difficult for them for the learners?

Teacher: Ah it is difficult for the learners because they are feeling lazy to read and practice.

Researcher: OK OK the next question what makes physical science difficult as a subject according to you in general the factors that make the subject to be difficult?

Teacher: Yah the subject is that the practical aspect makes the subject difficult.

Researcher: Ok the practical aspect of the subject, ok do you think is this the only factor that makes the subject to be difficult for these learners?

Teacher: Yah no at the same time physical science also is one of the subject that need more resource, so if you are teaching you don't have resource is going to be more difficult for to tell the learners.

Researcher: OK, OK thank you and then the next question does language affect, does language has an effect, does language has effect on the pass rate/ Especially in physical science.

Teacher: Yes the language affect because most of the question is English so our learners they find problem with the English language sometimes they don't understand the English so they find difficult to answer those question.

Researcher: OK OK what language will you prefer learners to study science with?

Teacher: I will prefer English, but the English they must get good foundation so that we come to, when you are when they are in secondary level there will be easy to read and understand the content.

Researcher: OK OK the next question, do you think that English language teachers must use science articles when they are teaching reading in their own classroom.

Teacher: Yes, because they must use those articles so that eh those learners who are doing science they will not find it difficult when it comes to only science aspects, they will know that in English also there is science hence also is there.

Researcher: OK OK the next, do you think that incorporating or integrating language especially reading strategies in science classroom can help learners in understanding the subject better?

Teacher: Yes.

Researcher: OK maybe if you try to explain.

Teacher: Yes because you know when you talk of science, science also goes with language like for example when doing practicals you must explain like when you are writing the methods you need English when you explain to somebody also you need English so if they are incorporative is going to help those learners.

Researcher: OK, OK the next question how does the language used in physical science compare with the language used in other discipline especially the terms, the terms we use in science how do they differ with the terms that the use let's say maybe in the subject like life orientation history, are the terms similar or different

Teacher: no the terms in physical science is different because those scientist there are different terminology that they are they are using. So is different is not the same.

Researcher: Ok maybe if you give examples maybe of the terms that you find in physical science but you don't find in other discipline.

Teacher: Yah when we talk of the Newton's laws when we talk about Newton everybody knows that we mention Newton we talk about science but when we talk about the other terms everybody knows that this is not science term, when we talk of Newton's laws those unit, then we know that this is science.

Researcher: OK OK ,I think this is the last one how best do think that physical science should be taught.

Teacher: Yes the best way physical science should be taught one is that the school must get the good resource at the same time teacher also must be well equipped, must be knowledgeable at the same time the learners must be cooperative with the teacher. Because the teacher can teach well if the learner they are lazy or they find it difficult to read or study is going to be difficult to the teacher and the learner.

Researcher: OK OKand then the last one what else will you like to add? Anything related to science or related to science teaching or anything?

Teacher: Yah what I want to say is that science is not difficult is challenging so but if in educators I wanna talk of educators, educators they should not be lazy at the same time you must always be reading, practicing attend workshops at the same time the regional office must organize workshops for educators so that will know new content, they will know what is going on and when it comes to the, learners also, learners also they should not be lazy they should not think that the subject is difficult is challenging but not difficult.

Researcher: OK, no thank you Mr…eh for all your inputs as we promised that this information will be confidential and another thing if maybe after reporting and everything if you want to see the results or the report will be available for you . Thank very much.

Teacher: Thank you very much.

Researcher: Thank you.

APPENDIX 19

RAW MARKS FOR THE CONTROL GROUP

LEARNERS	POST-TEST	%		PRE-TES	%
MAXIMUM MARKS	50	100		50	100
1	21	42		10	20
2	14	28		10	20
3	9	18		6	12
4	12	24		0	0
5	11	22		4	8
6	12	24		10	20
7	12	24		0	0
8	19	38		4	8
9	30	60		8	16
10	13	26		2	4
11	11	22		2	4
12	21	42		3	6
13	15	30		8	16
14	11	22		3	6
15	23	46		2	4
16	11	22		4	8
17	14	28		6	12
18	21	42		4	8
19	14	28		2	4
20	24	48		4	8
21	32	64		10	20
22	14	28		4	8
23	15	30		4	8
24	21	42		4	8
25	12	24		10	20
26	10	20		12	24
27	12	24		6	12
28	22	44		6	12
29	10	20		2	4
30	9	18		2	4
31	16	32		6	12
32	14	28		8	16
33	12	24		4	8
34	16	32		4	8

APPENDIX 20

RAW MARKS FOR THE EXPERIMENTAL GROUP

LEARNERS	POST-TEST	%		PRE-TEST	%
MAXIMUM MARKS	**50**	**100**		**50**	**100**
1	21	42		8	16
2	31	62		2	4
3	9	18		6	12
4	11	22		5	10
5	16	32		0	0
6	27	54		8	16
7	41	82		2	4
8	17	34		6	12
9	28	56		2	4
10	37	74		8	16
11	12	24		1	2
12	21	42		4	8
13	25	50		0	0
14	16	32		6	12
15	7	14		4	8
16	21	42		4	8
17	25	50		2	4
18	38	76		0	0
19	11	22		6	12
20	16	32		10	20
21	12	24		6	12
22	14	28		0	0
23	34	68		9	18
24	11	22		8	16
25	23	46		10	20
26	43	86		4	8
27	14	28		4	8
28	29	58		8	16
29	23	46		6	12
30	23	46		6	12
31	16	32		6	12
32	40	80		6	12
33	48	96		0	0
34	17	34		6	12